City of Santa Fe Water System

Source Water Protection Plan

DRAFT

April 2021

DRAFT Source Water Protection Plan

for the City of Santa Fe Water System

Santa Fe, New Mexico

PWS #3505126

Prepared in coordination with

New Mexico Environment Department
Drinking Water Bureau
1190 S St Francis Dr
Santa Fe, NM 87505

DRAFT
April 2021

CONTACTS & RESOURCES
City of Santa Fe – Water Division Alan Hook, Water Resources Coordinator Assistant / 505-955-4205 / aghook@santafenm.gov https://www.santafenm.gov/water_division
New Mexico Environment Department – Drinking Water Bureau – Sustainable Water Infrastructure Group Lena Schlichting, Source Water Protection Program Manager / 505-660-3391 / lena.schlichting@state.nm.us https://www.env.nm.gov/drinking_water/source-water-protection/

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ABBREVATIONS AND ACRONYMS

ac-ft	acre-foot
BDD	Buckman Direct Diversion
bgs	below ground surface
BMP	best management practice(s)
BTEX	benzene, toluene, ethylbenzene, total xylenes
CAF	Corrective Action Fund
cfs	cubic feet per second
CSF	City of Santa Fe
CWA	Clean Water Act
DRO	diesel range organics
DWB	Drinking Water Bureau (NMED)
EDB	1,2-dibromoethane (ethylene dibromide)
EDC	1,2-dichloroethane (ethylene dichloride)
EPA	United States Environmental Protection Agency
gpm	gallons per minute
GRO	gasoline range organics
LANL	Los Alamos National Laboratory
LNAPL	light non-aqueous phase liquid
LUST	leaking underground storage tank
MCL	maximum contaminant level
MS4	Municipal Separate Storm Sewer System (NPDES permit)
NEPA	National Environmental Policy Act
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NPDES	National Pollutant Discharge Elimination System
ORO	oil range organics
PAH	polycyclic aromatic hydrocarbons
PCE	tetrachloroethylene
PNM	Public Service Company of New Mexico
PSOC	potential source of contamination
PSTB	Petroleum Storage Tank Bureau (NMED)
PWS	public water system
QWEL	Qualified Water Efficient Landscape
RCRA	Resource Conservation and Recovery Act
SCP	State Cleanup Program
SOC	source of contamination (*implies actual source*)
SWP	source water protection
SWPA	source water protection area
SWPP	source water protection plan
TCE	trichloroethylene
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
USFR	Upper Santa Fe River
USFS	United States Forest Service
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
VRP	Voluntary Remediation Program

EXECUTIVE SUMMARY

The City of Santa Fe Water System is dedicated to providing a safe, reliable, and resilient water supply to meet the community's needs. Source waters that are secure both in quality and quantity are essential for a high quality of life and the prosperity of the City and its residents. The purpose of this Source Water Protection Plan is to provide an effective planning tool for the City of Santa Fe to protect its sources of drinking water.

The City of Santa Fe Water System is unique among public water systems in the Southwest due to its diverse portfolio of source waters, including two groundwater well fields, surface water from the Santa Fe River stored in two reservoirs, and surface water from the San Juan-Chama Project obtained from the Rio Grande at the Buckman Direct Diversion. The City purchases water from the latter, a separate public water system, and only the groundwater and Santa Fe River source waters are discussed in this plan.

Organized municipal water use in Santa Fe has a long history that stretches back to the 17th century. Population growth in the mid- to late 20th century required vast upgrades to the City's water system, which previously depended on water from the Santa Fe River only. The City and Buckman well fields were developed in the 1950s and 1970s, respectively, and were used so extensively that groundwater depletion was evident within only a few decades. More recently, the City has shifted back to using more surface water, both from the Santa Fe River and the Rio Grande, greatly decreasing pumping pressure in the well fields. This is the cornerstone of a more sustainable and resilient drinking water portfolio under changing climatic conditions.

The New Mexico Environment Department (NMED) conducted an initial source water assessment for Santa Fe in 2003 that was later revised by NMED's contractor, Daniel B. Stephens & Associates Inc. The current plan includes a source water assessment and contaminant source inventory that is up to date as of spring 2021.

Source water areas are defined for each of the Santa Fe Water System's 20 active groundwater wells using either 15- or 35-year modeled capture zones (City Well Field) or a fixed-radius method (Buckman Well Field) based on available data. The entire Upper Santa Fe River watershed above Two Mile Reservoir is considered a source water protection area, within which sub-catchments have been identified as having low to high post-fire threats, such as debris flows, capable of impacting the City's source water storage in McClure and Nichols reservoirs.

Existing and potential sources of contamination were identified and assessed for the level of risk (very low to very high) they pose to the water supply within each source water protection area based on the potential or actual impact to the water system and the probability of that impact occurring. The primary risks to the City's water supplies include contamination at the former Santa Fe Generating Station and several leaking underground petroleum storage tank sites in the City Well Field; naturally occurring arsenic and uranium in the Buckman Well Field; and potential wildfire-related threats in the Upper Santa Fe River Watershed. Other risks are typically lower and include non-leaking underground petroleum storage tanks, stormwater pollutants, arroyos and acequias, commercial enterprises such as automotive facilities, private domestic or irrigation wells, and septic systems.

The City of Santa Fe Source Water Protection team has identified a series of action items and recommendations key to preserving the quality and quantity of the City's source waters. These include improvements to ongoing water conservation programs, expanded outreach opportunities, regulatory actions through ordinances, and additional monitoring and modeling efforts. This Source Water Assessment and Protection Plan should be updated every two years with technical and public input.

1.0 INTRODUCTION

1.1 Protecting Your Drinking Water through Source Water Protection Planning

Access to safe, clean drinking water is a right to every New Mexican and is a key component in maintaining a healthy and viable community. All drinking water sources are vulnerable to contamination from a variety of human activities. Without attention to managing these potential sources of contamination, communities will be faced with increased costs and potential loss of their drinking water sources. Water sources in New Mexico are also highly vulnerable to depletion through unsustainable use and drought. Careful planning for and monitoring of source water supplies are invaluable.

Applying proactive measures through source water protection planning is less expensive than remediation and more reliable over the long term. If an aquifer that supplies drinking water to a community becomes contaminated, the cost of restoring clean drinking water far exceeds the costs of water treatment alone. The underlying principle in Source Water Protection (SWP) is that prevention is the most effective and efficient method to assure long-term safe drinking water.

Source Water Protection Plans (SWPPs) go beyond a basic source water assessment to create an effective management tool with strategies for protecting a community's source of drinking water. SWPPs not only provide a source water contaminant inventory and risk assessment, but include water system and hydrogeologic information, source water area maps, best management practices, and action items developed by the public water system through a public participation process.

The purpose of this document is to provide an effective planning tool for the City of Santa Fe Water System to protect its sources of drinking water. This Source Water Protection Plan has been developed in coordination with the New Mexico Environment Department (NMED) following standard guidelines for source water plans developed by the U.S. Environmental Protection Agency (EPA) and NMED. This document is designed to provide relevant information that informs sustainable source water management and that can be easily updated.

1.2 Source Water Protection Program for Public Water Systems

The U.S. Congress amended the Safe Drinking Water Act in 1996 to provide for the assessment and protection of sources of public water supply. The EPA provides guidance and encourages partnerships for the voluntary process of source water protection planning. States, including New Mexico, completed source water assessments between 2002 and 2006 for all public water systems and are now implementing strategies to help local communities use and update the information obtained from these assessments.

Source water protection plans are living documents designed to be updated and improved as a water system acquires greater data and understanding of potential threats to its source water. This is accomplished through multiple phases broadly categorized as assessment as described above (determining contamination threats) or protection (planning and mitigation against those threats). Figure 1-1 shows the basic components of source water protection.

Figure 1-1 Elements of source water protection programs. SWAP = source water assessment plan; SWPP = source water protection plan. Modified from Colorado Department of Public Health & Environment – Water Quality Control Division.

NMED Drinking Water Bureau's Source Water Protection Program works with individual water systems, such as the City of Santa Fe Water System, with input from the community and other interested parties. The program assists in the development of a Source Water Protection Plan that is unique to each individual system and offers ways to identify potential sources of contamination and other threats to drinking water, while designing a plan that will protect water systems.

2.0 SOURCE WATER PROTECTION PLANNING TEAM AND STAKEHOLDERS

The Source Water Protection Team (Table 2-1) plays a critical role in the development of the source water assessment and protection plan as well as implementing recommendations outlined in the plan. Collaboration with water system representatives, water consumers, and community stakeholders will ensure the success of the City of Santa Fe SWPP.

Table 2-1 City of Santa Fe Source Water Protection team

Name	Title	Affiliation
Alan Hook	Water Resources Coordinator Assistant	City of Santa Fe, Water Division
Zoe Isaacson	River and Watershed Project Admin.	City of Santa Fe, Public Works-Engineering
Melissa McDonald	River and Watershed Manager	City of Santa Fe, Public Works-Engineering
Alex Puglisi	Environmental Compliance Specialist	City of Santa Fe, Water Division (*former*)
Andy Jochems	Source Water Specialist	NMED DWB Source Water Protection Program
Lena Schlichting	Program Manager	NMED DWB Source Water Protection Program
Jill Turner	Group Manager	NMED DWB Sustainable Water Infrastructure

3.0 WATER SYSTEM INFORMATION

3.1 Historical Water Infrastructure

Spanish expeditions to the Santa Fe area in 1590 and 1591 reported Tewa pueblo fields irrigated by canal systems (Hammond and Rey 1966). The antiquity of these water systems is not well constrained, but they were certainly front-runners to the numerous *acequias* found throughout northern New Mexico, including two *acequia madres* constructed around the time that the Villa de Santa Fe was established by royal charter in 1610. A 1776 report attests to the struggles of Santa Fe's expanding irrigation system (Adams and Chavez 1956):

> Indeed, it [the Santa Fe River] is usually insufficient, at the best season for irrigating the farms, because there are many of them [*acequias*] it does not reach the lowest ones, for the first, being higher up, keep bleeding it off with irrigation ditches, and only in a rainy year is there enough for all.

By the late 19th century, Santa Fe's expanding population and agricultural practices warranted new efforts to boost the area's water supply (Figure 3-1). Stone Dam was built by the Santa Fe Water and Improvement Company on the Santa Fe River in 1881, creating a reservoir storage of about 25 acre-feet (ac-ft). A 10-inch cast-iron pipe delivered water from the dam to Santa Fe Plaza with service lines for residents along its 16,450-foot length (Smith 1957).

The City of Santa Fe was incorporated in 1891 and authorized Santa Fe Water and Improvement Company to construct a new dam a half-mile downstream of Stone Dam on the Santa Fe River. Two Mile Reservoir, so named for its location two miles from Santa Fe Plaza, was completed in 1893, breaching and covering Stone Dam in the process (Duran and Thomas 2020). Two Mile Reservoir had a storage capacity of 500 ac-ft. The New Mexico Office of the State Engineer and the Army Corps of Engineers decommissioned the reservoir in 1992 due to hazardous and unstable conditions, and indeed the dam was breached two years later (Lewis 1996).

Figure 3-1 One of two original acequia madres in Santa Fe, New Mexico, ca. 1890. Photographer unknown. Courtesy of Palace of the Governors Photo Archives (NMHM/DCA, Negative No. 055021).

Poor water pressure in the South Capital District led the City to construct Atalaya Hill Reservoir in 1895. This reservoir improved water pressure for residents for more than 75 years before it was decommissioned when a pump station was built at Canyon Road and Camino Cabra (Duran and Thomas 2020).

The City relied solely on Santa Fe River water before rapid population growth in the mid- to late 20th century (Figure 3-2). The City Well Field began operation in the late 1940s to early 1950s, coinciding with a period of drought that lasted until about 1960. Drilling in the Buckman Well Field began in the early 1970s, initiating several decades of increasing reliance on groundwater that culminated with significant over-pumping in the mid-1990s. The City purchased the Sangre de Cristo Water Company from the Public Service Company of New Mexico (PNM) in 1995.

The completion of Buckman Direct Diversion (BDD; NM3502826) in 2011 represented a critical expansion of the City's drinking source water portfolio. This marked the first diversion of San Juan-Chama Project surface water (via the Rio Grande) to Santa Fe. Vigorous conservation measures and initiatives paired with this newly available source water have diminished the City's reliance on groundwater, providing optimism for safer and more sustainable water resources under a changing climate in the 21st century.

3.2 Modern Water System

The City of Santa Fe Water System is a public, community water system as defined by the New Mexico Drinking Water Regulations 20.7.10 NMAC (New Mexico Administrative Code). The system directly serves approximately 78,200 customers through 33,297 metered connections and sells water to four public water systems:

- Christus St. Vincent Medical Center (NM3580026)
- Las Campanas Water System (NM3500626)
- Santa Fe County South Sector (NM3500826)
- Santa Fe County West Sector (NM3500926)

In total, the City of Santa Fe system serves a population of 90,810, making it the fourth-largest system in New Mexico.

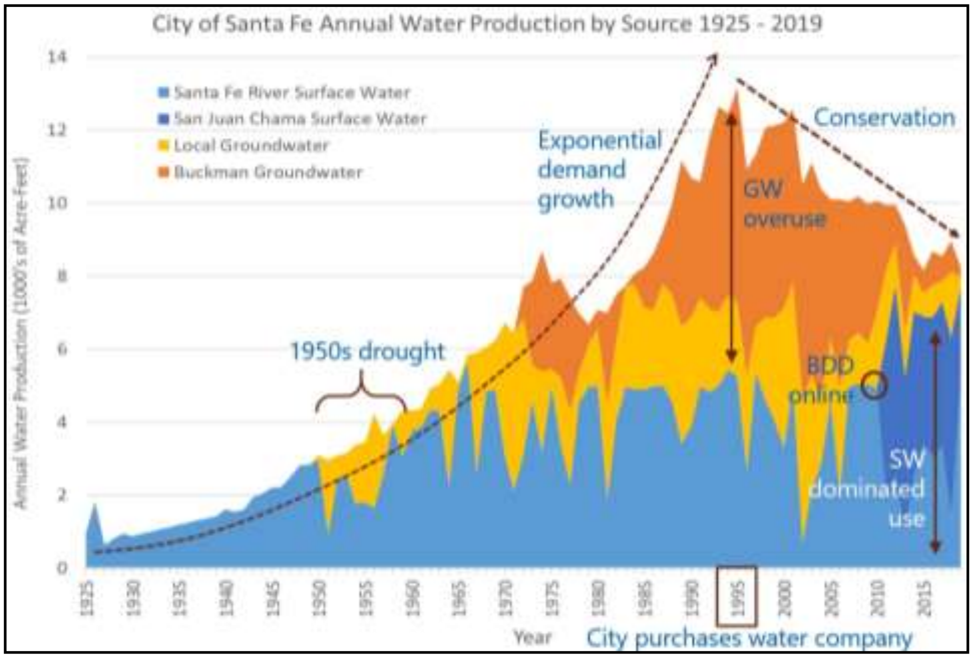


Figure 3-2 Population growth and water production for the City of Santa Fe over the period 1925-2019. Modified from City of Santa Fe Water Division.

The City of Santa Fe Water System is comprised of four sources: surface water from the upper Santa Fe River watershed, San Juan-Chama surface water purchased from BDD, and groundwater pumped from the Buckman and City well fields (Figure 3-3). From 2013 to 2019, the approximate average contributions of Santa Fe River surface water, Rio Grande surface water, and ground water were 35%, 45%, and 20%, respectively (Figure 3-4). However, as much as 80% of the City's water is derived from BDD at certain times of the year. The 2013-2019 average annual production from all sources was 8,600 ac-ft.

The City of Santa Fe Water System consists of the following infrastructure (NMED 2018):

- 20 active production wells (13 Buckman Well Field, 7 City Well Field)
- 2 surface water reservoirs
- 1 connection to the Buckman Regional Water Treatment Plant where BDD water is treated
- 8 consecutive connections (4 each to the Santa Fe County South and West Sector systems)

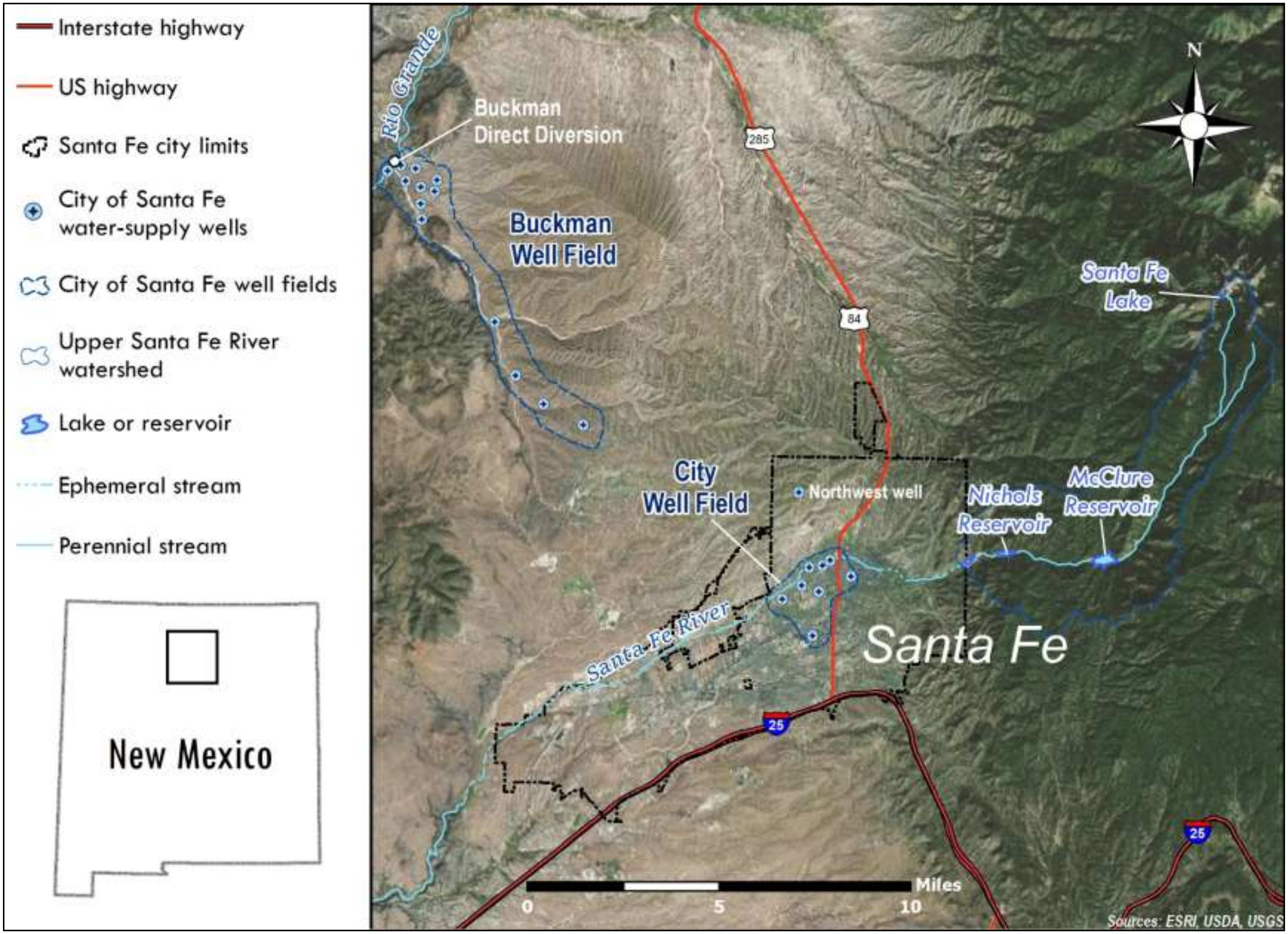


Figure 3-3 Geographic setting of City of Santa Fe water system.

Table 3-1 Well information for the Buckman and City well fields

Name	Drill Date	Well Depth (ft)	Casing Depth (ft)	Casing Diameter (in)	Static Water Level (ft bgs)	Date of Static Water Level	2017 Production (ac-ft)	Pump Rated Capacity (gpm)	Pump Setting (ft)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)
Buckman – Active Wells											
Well 1	1977	1,108	1,093	16	188.50	2015	95.16	546	840	257	1,093
Well 2	1977	1,593	1,473	16	107.12	2015	0.16	534	680	234	1,578
Well 3A	1995	1,500	1,490	1	138.67	2015	21.35	350	350	500	1,490
Well 4	1972	1,219	1,219	16	73.65	2015	—	374	750	454	1,214
Well 5	1972	1,182	1,182	16	154.51	2015	16.83	294	750	244	1,170
Well 6	1972	1,154	951	16	136.45	2015	1.81	766	730	291	1,148
Well 7	1990	1,415	700	16	167.06	2015	2.33	700	800	700	1,400
Well 8	1990	910	380	16	30.95	2015	63.91	530	620	380	900
Well 9	2002	1,363	1,336	16 / 12	181.10	2015	1.03	390	—	320	1,320
Well 10	2003	2,016	2,000	18 / 14	334.97	2015	47.21	1,100	—	500	1,980
Well 11	2003	2,020	—	18 / 14	396.41	2015	0.16	950	—	450	1,980
Well 12	2003	1,930	1,920	18 / 14	399.85	2015	0.12	850	—	400	1,900
Well 13	2003	2,018	2,000	18 / 14	315.41	2015	9.84	1,250	—	500	1,980
Buckman – Inactive Wells											
Well 3	1972	1,500	—	16	—	—	—	—	—	500	1,480
City – Active Wells											
Agua Fria	1951	740	740	16	174.80	2018	2,565.10	800	400	201	740
Alto	1968	741	725	12.75	201.00	2019	0.01	250	609	226	720
Ferguson	1970	826	750	14	227.00	2019	4.88	270	610	175	246
Northwest*	1998	2,000	500	14.625	475.87	2019	112.21	960	760	500	2,000
Osage	1971	809	770	—	116.80	2019	1.59	500	428	210	760
St. Michaels	1983	800	797	16	250.70	2018	0	490	714	382	782
Torreon	1997	1,230	1,230	16	103.70	2019	19.90	400	504	400	1,200
City – Inactive Wells											
Acres Estates*	1947	410	—	—	—	—	—	—	—	—	—
Country Club*	1973	493	—	—	303	2007	—	—	—	—	—
Hickox	1946	255	217	8	212.60	2019	—	—	—	76	210
Santa Fe	1951	1,523	725	16	308.60	2019	124	220	550	200	725

*These wells are not part of the City Well Field but are categorized as such for convenience.

ac-ft   acre-feet (the volume needed to cover one acre in one foot of water; 1 ac-ft = 325,851 gallons)
bgs   below ground surface
gpm   gallons per minute
—   not available

- 7 treatment plants/units
- 12 booster/pump stations
- 9 storage tanks (combined storage volume of 35 million gallons)
- 12 pressure zones
- Approximately 565 miles of water mains

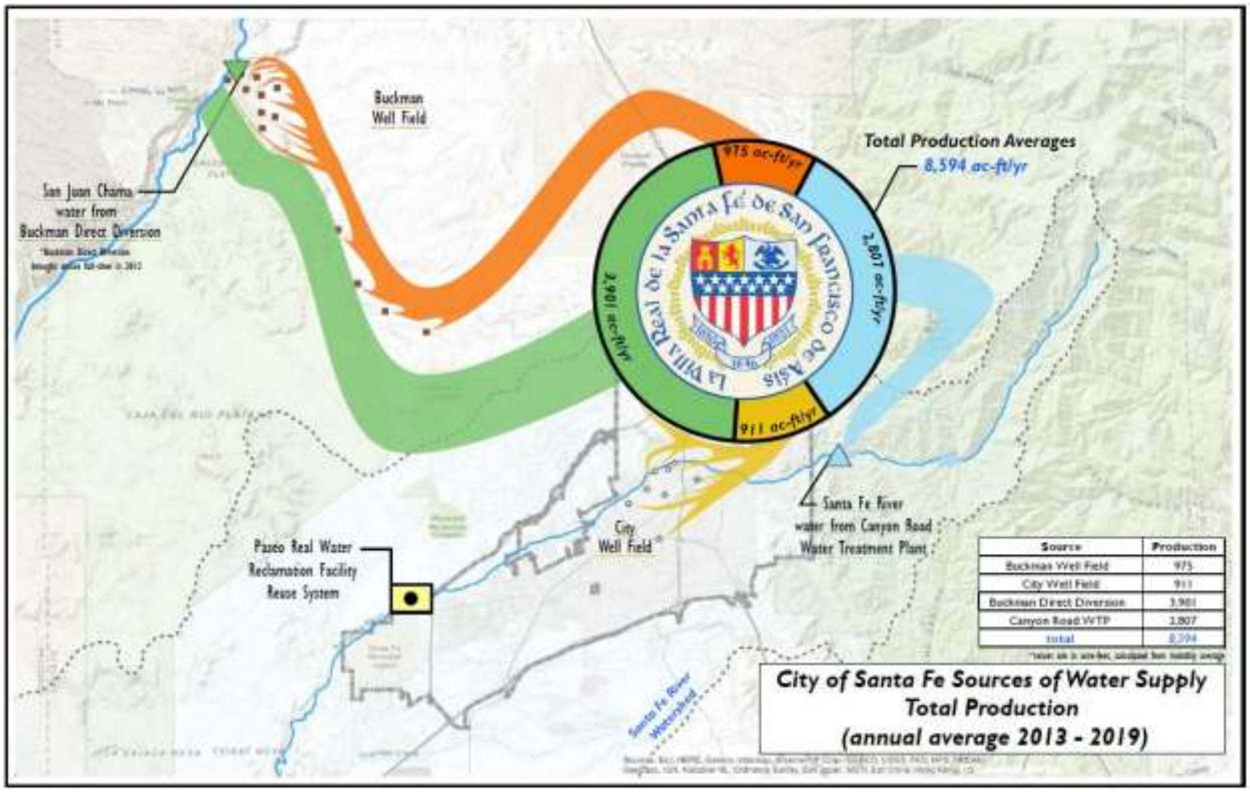


Figure 3-4 Average annual potable water production, 2013-2019. Modified from City of Santa Fe Water Division.

If needed, the City can move water between the pressure zones according to customer demand and distribution pressures. Several zones include parts of Santa Fe County water systems.

Table 3-1 provides well construction and water level information for the Buckman and City well fields. The City's annual groundwater rights for the Buckman and City well fields are 10,000 ac-ft and 4,865 ac-ft, respectively. In 2019, groundwater accounted for only 7% of the City's total production following a robust winter snowpack (CSF 2020).

Figure 3-5 Draining of McClure Reservoir in preparation for renovations, November 30, 1946. Photograph by T.H. Parkhurst. Courtesy of Palace of the Governors Photo Archives (NMHM/DCA, Negative No. 068847)

The City maintains two reservoirs, McClure and Nichols, in the Upper Santa Fe River (USFR) watershed with a combined storage capacity of nearly 4,000 ac-ft. McClure Reservoir, originally called Granite Point Reservoir, was completed in 1929 with a dam constructed of earth and concrete (Figure 3-5). The dam was raised in 1935, 1947, and again in 1995 when 500 ac-ft of storage rights previously assigned to Two Mile Reservoir were transferred for a total of 3,255 ac-ft (Lewis and Borchert 2009). Granite Point Reservoir was renamed to McClure Reservoir in 1946 for Thomas M. McClure, New Mexico State Engineer in the 1930s and 1940s (Townsend 2015).

After renovating Granite Point Reservoir in 1935, New Mexico Power Company applied for the construction of Four Mile Reservoir which was completed in 1943 with a storage capacity of approximately 775 ac-ft. Four Mile Reservoir was constructed in a similar fashion as McClure Reservoir (earth and concrete) and its crest and spillway were renovated in 1995 and the early 2000s (Lewis and Borchert 2009). It was renamed for C.H. Nichols, a major investor in the development of the upper Santa Fe River watershed (Duran and Thomas 2020). Further information about McClure and Nichols Reservoirs is provided in Table 3-2.

Table 3-2 McClure and Nichols Reservoir details

Name	Year Completed	Dam Length (ft)	Dam Height (ft)	Maximum Discharge (cfs)	Maximum Storage (ac-ft)	Normal Storage (ac-ft)	USFR Drainage Area (mi^2)
McClure Reservoir	1929	759	126	17,980	4,278	3,282	17.5
Nichols Reservoir	1943	622	91	19,690	1,234	679	22

NOTE: Information from New Mexico Office of the State Engineer
cfs cubic feet per second.

The City's annual water right for McClure and Nichols Reservoirs is 4,000 ac-ft. Of this, 2,939 ac-ft are subject to regulations of Rio Grande Compact Article VII, meaning that some or all of this amount may be released from storage as part of New Mexico's downstream obligations to Texas (Lewis and Borchert 2009). To date, the City has avoided this tenuous situation by utilizing relinquishment credits granted when New Mexico delivers more than its annual obligation. The amount of water stored in the reservoirs is monitored by U.S. Geological Survey (USGS) gaging stations 0831550 at McClure Reservoir and 08316500 at Nichols Reservoir.

Additional information on the Santa Fe system, including water quality testing data, can be found on the NMED's Drinking Water Watch website at https://dww.water.net.env.nm.gov/NMDWW/ and the City of Santa Fe Water Division website at https://www.santafenm.gov/water.

4.0 SETTING

4.1 Source Water Protection Area: City Well Field

4.1.1 Physical Geography and Geology

The City of Santa Fe is located in the southern Española Basin, a structural and hydrogeologic basin in the Rio Grande rift region of the Basin and Range physiographic province. Most of the City lies on a low-gradient piedmont plain formed where the ancestral Santa Fe River and smaller streams exited their headwaters in the southern Sangre de Cristo Mountains, also known as the Santa Fe Range (Spiegel and Baldwin 1963). The Santa Fe Range is the southern terminus of the Rocky Mountains.

North of Agua Fria Street and west to the village of Agua Fria, the Santa Fe River defines an approximate boundary between a relatively flat but subtly terraced landscape to the south where most of the City of Santa Fe is located and an upland area to the north known as Tano Ridge. The seven water-supply wells of the City Well Field are located in the piedmont slope area except for the Northwest Well in the upland Tano Ridge area.

Both Tano Ridge and the gentle plain on which Santa Fe is located are underlain by sediments deposited in a Rio Grande rift basin that has gradually subsided over the last 30 million years (Koning et al. 2013). In a seminal study on the geology and hydrology of the Santa Fe area, Zane Spiegel and Brewster Baldwin of the U.S. Geological Survey named this basin-fill sediment the Santa Fe Group (Spiegel and Baldwin 1963). The Santa Fe Group is 2,500-3,000 feet thick in the vicinity of the City Well Field (Grauch et al. 2009).

Certain formations within the Santa Fe Group host aquifers of varying area and depth. Of particular interest is the Tesuque Formation (Figure 4-1), a collection of channel, floodplain, and piedmont sediments deposited by the ancestral Santa Fe River and other streams on alluvial fans emanating from the Santa Fe Range mountain front (Smith 2000). Local geologic units, including the Tesuque Formation, are described in Table 4-1.

It is important to distinguish between the different Tesuque Formation deposits in the subsurface because they have different aquifer properties. For example, one lithosome (a body of rock with uniform lithologic character) within the Tesuque Formation consists of permeable sandstones deposited in former channels of the ancestral Santa Fe River (Koning and Read 2010). The percentage of these channel deposits increases upward in the Tesuque Formation, and it is this lithosome that hosts the regional aquifer tapped by the City's production wells. Beds of the Tesuque Formation are tilted 10-15° to the west (Hawley 2016), and the wells of the City field are therefore completed in different intervals of the formation (Figure 4-2).

A thin (less than 75 ft) package of deposits overlying the Tesuque Formation is mostly unsaturated, but older homes and businesses in the City produced water from wells hand-dug to a shallow aquifer at the base of this zone (Lazarus and Drakos 1995). These sediments consist of permeable sand and gravel deposited again by an ancestral Santa Fe River and smaller tributaries exiting the Santa Fe Range but at a later time than the Tesuque Formation.

The post-Tesuque deposits are grouped into: (1) the approximately 3.5- to 1-million-year-old Ancha Formation, the uppermost unit of the Santa Fe Group (Koning et al. 2002); and (2) three younger inset stream terrace deposits ranging in age from hundreds of thousands to only a few hundred years old (Hawley 2016). Santa Fe Plaza is located on the youngest terrace surface and the State Capitol is located on the oldest, although the elevation change between their surfaces is largely obscured by development.

The shallow aquifer is primarily recharged along the Santa Fe Range mountain front. Some of this recharge water migrates to the deeper regional aquifer (Tesuque Formation) through seasonal infiltration along streambeds of modern arroyos and unlined acequias crossing the surfaces of older terrace deposits (Lazarus and Drakos 1995). Infiltration is especially focused at high-permeability fractures, faults, or bedding planes acting as conduits between the Tesuque Formation and younger deposits above it. As a result, the shallow aquifer is typically not observed in wells located more than 1.5 miles from the mountain front, and nowhere does it produce sufficient water for municipal use. The role of soils in infiltration and other processes of the hydrologic cycle is diminished in the City Well Field due to the prevalence of paved, impermeable surfaces.

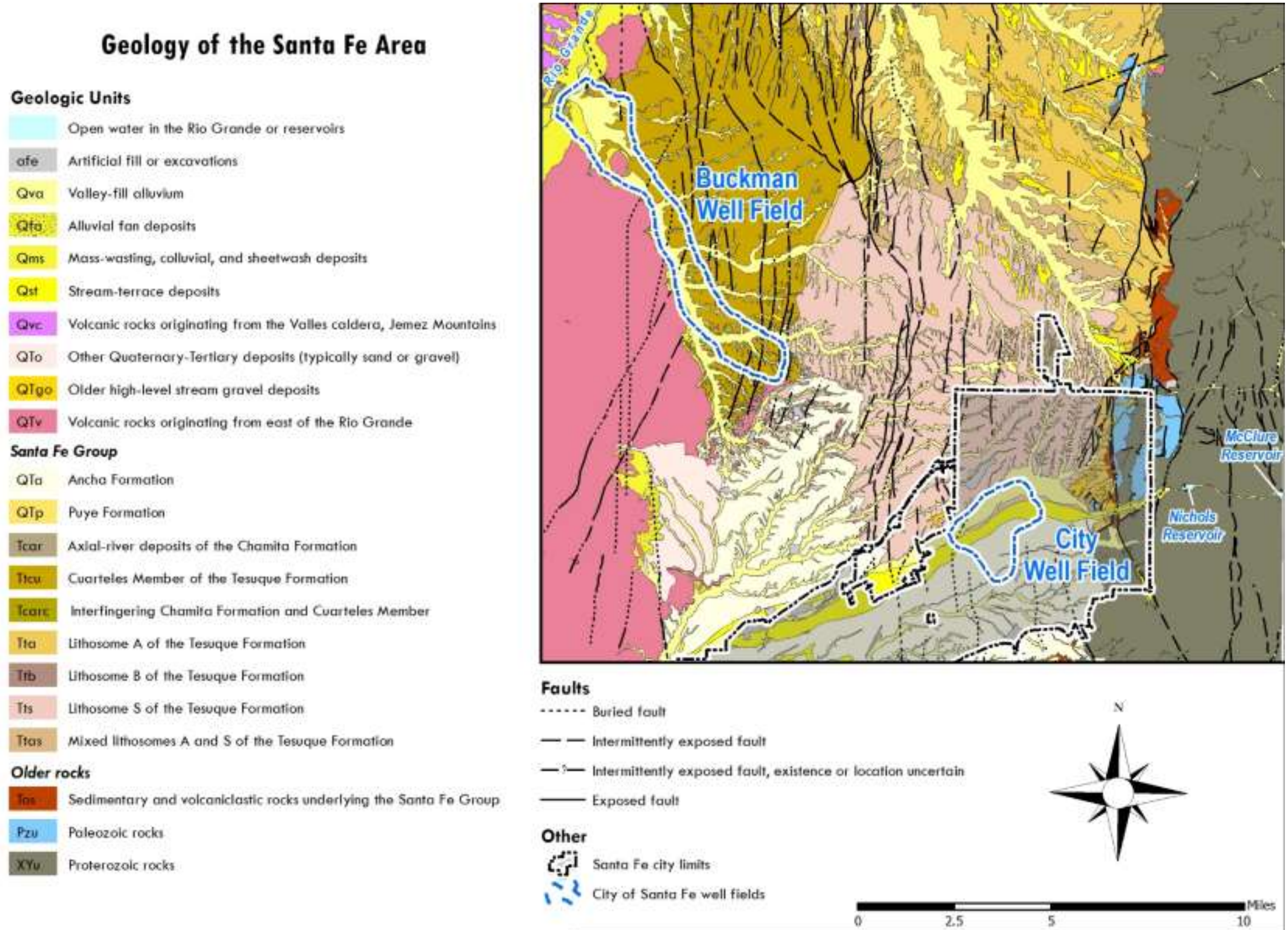
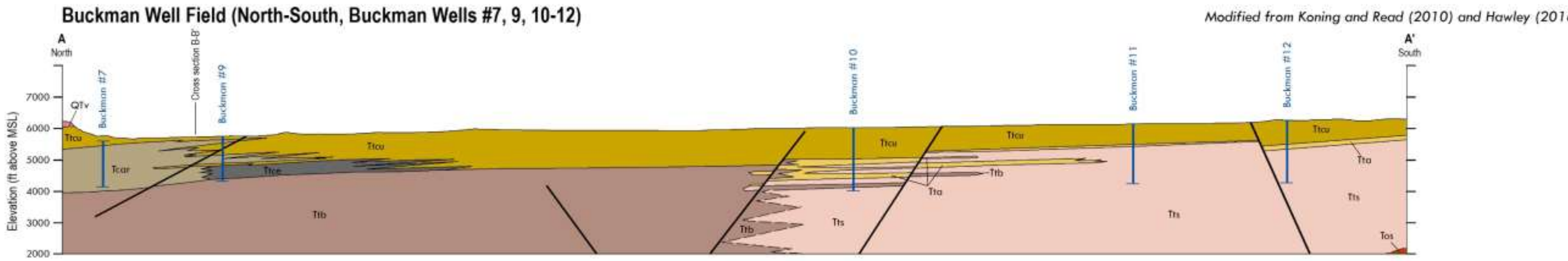


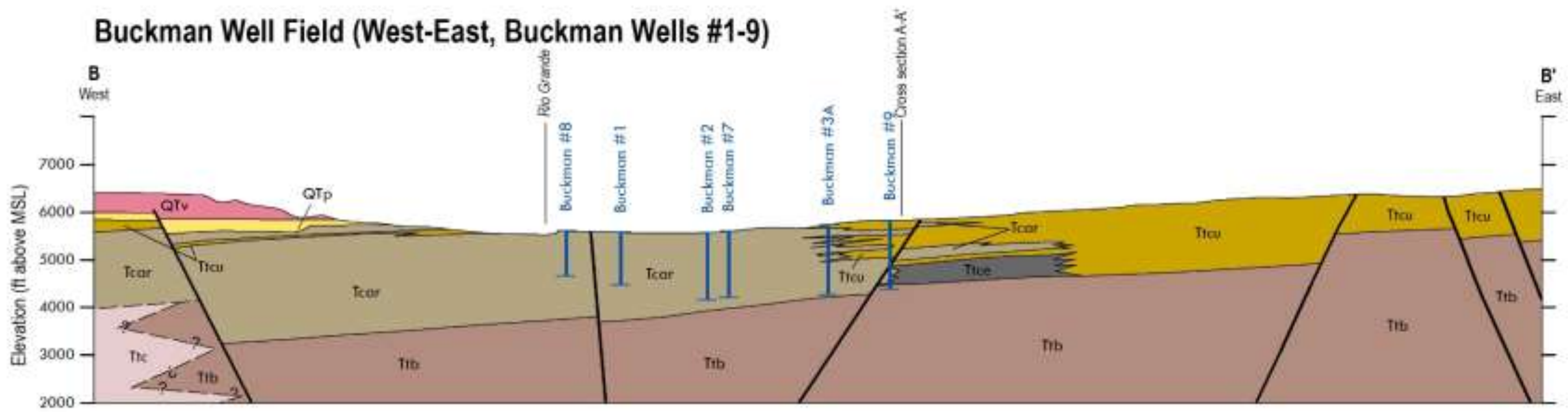
Figure 4-1 Generalized geologic map of the Santa Fe area encompassing the Buckman and City well fields. Modified from Koning and Read (2010).

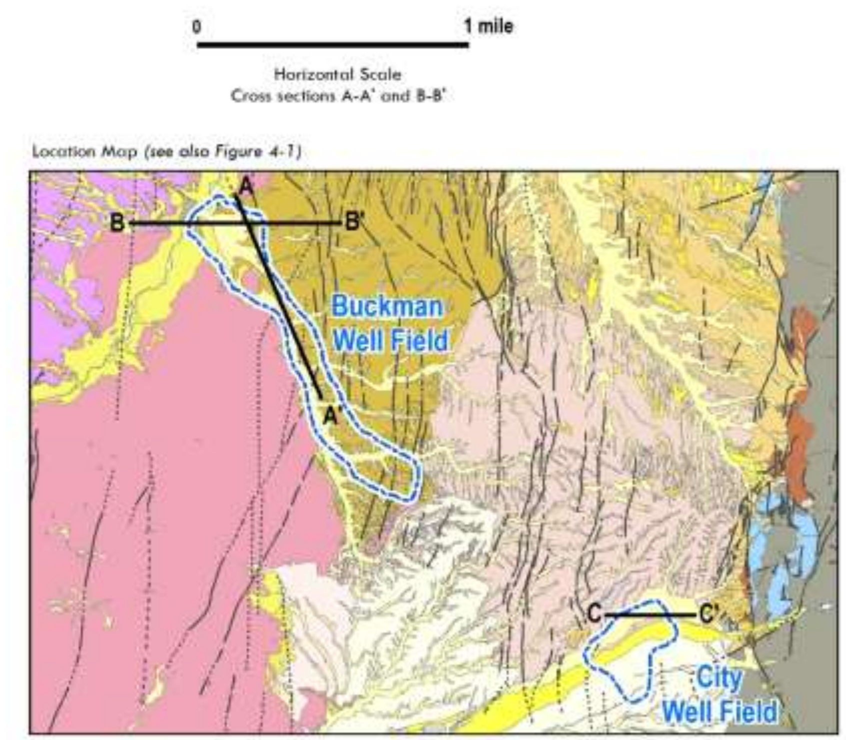
Table 4-1 Descriptions for lithologic units in the Santa Fe area as shown in Figure 4-1 (modified from Koning and Read 2010)

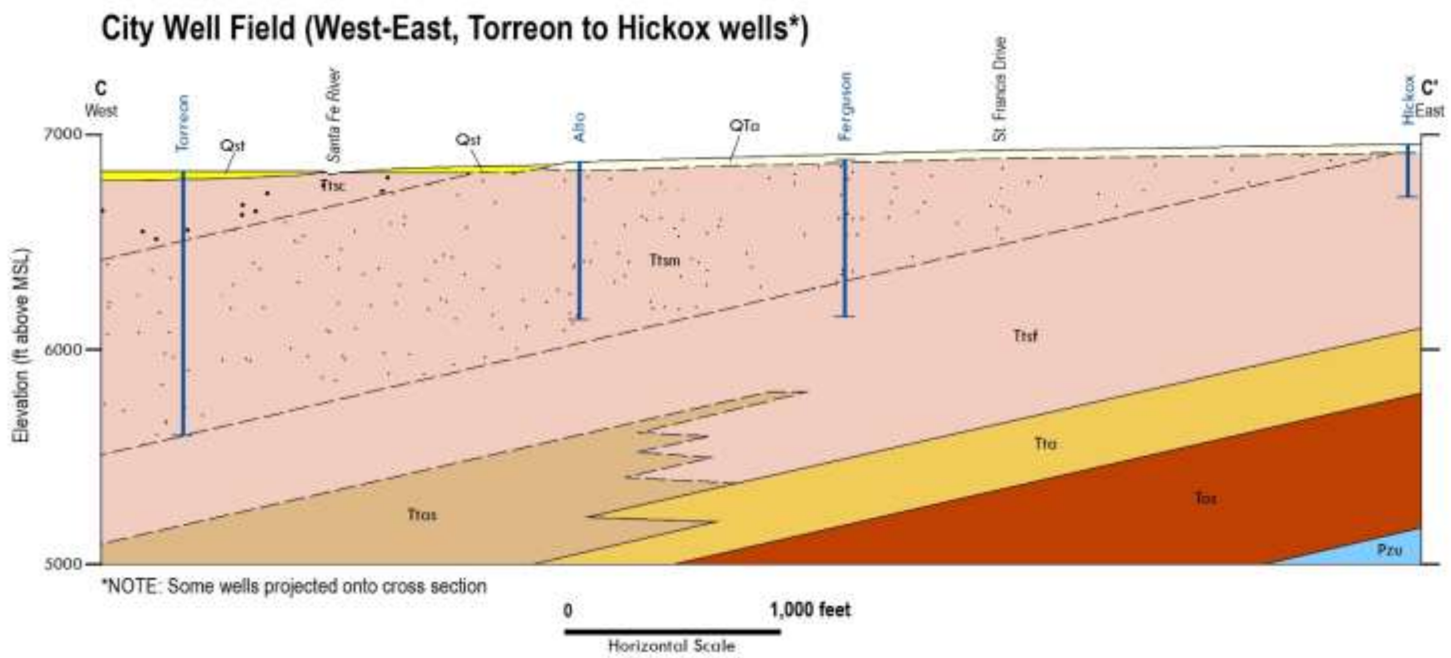
Abbreviation	Unit Name	Brief Description
afe	Artificial fill or excavations	Deposits under highways or in landfills
Qva*	Valley-fill alluvium	Sand and gravel deposited in valley floors and often cut by arroyos
Qfa	Alluvial fan deposits	Gravel and sand deposited in fan-shaped lobes at the mouths of drainageways
Qms	Mass-wasting, colluvial, and sheetwash deposits	Sheetflood sand, coarse landslide or slump deposits, and gravelly talus or colluvium
Qst	Stream-terrace deposits	Sand and gravel underlying terraces perched above active drainageways
Qvc	Volcanic rocks originating from the Valles caldera	Ash and ash-flow tuffs resulting from powerful eruptions of the Valles caldera over the last 1,600,000 years
QTo	Other Quaternary-Tertiary deposits (sand or gravel)	Gravel and sand consisting of volcanic rocks deposited east of the Caja del Rio Plateau
QTgo	Older high-level stream gravel deposits	Sandy gravel underlying terraces on Tano Ridge and north of the Río Tesuque that are perched higher above active drainageways than those of unit *Qst*
QTv	Volcanic rocks originating from east of the Rio Grande	Basaltic to andesitic rocks capping the Caja del Rio Plateau or monzonitic intrusive rocks near La Cienega
Santa Fe Group		
QTa*	Ancha Formation	Sand and gravel derived from the southwestern Sangre de Cristo Mountains and deposited on alluvial slopes
QTp	Puye Formation	Volcanic-rich gravel, sand, and silt deposited by streams and debris flows west of the Rio Grande
Tcar*	Axial-river deposits of the Chamita Formation	Sandstones deposited by the ancestral Rio Grande
Ttcu	Cuarteles Member of the Tesuque Formation	Conglomerate and sandstone deposited on alluvial slopes
Tcarc	Interfingering Chamita Fm and Cuarteles Mbr	Complexly interfingering conglomerate and sandstone of units *Tcar* and *Ttcu*
Tta	Lithosome A of the Tesuque Fm	Sandstone and subordinate mudstone deposited on alluvial slopes that complexly interfingers and grades laterally or vertically into units *Ttb*, *Tts*, and *Ttcu*
Ttb	Lithosome B of the Tesuque Fm	Claystone, siltstone, and sandstone deposited on floodplains in a basin-floor setting
Tts*	Lithosome S of the Tesuque Fm	Pebbly sandstone, siltstone, and mudstone deposited by the ancestral Santa Fe River in its channel or on its floodplain
Ttas	Mixed lithosomes A and S of the Tesuque Fm	Gradational zone between units *Tta* and *Tts* northwest of the Pueblo of Tesuque
Older Rocks		
Tos	Sedimentary, volcaniclastic rocks under the Santa Fe Group	Includes ash-rich sandstone and siltstone of the Abiquiu Formation, alluvial-fan sandstone and conglomerate or tuffaceous sandstone of the Espinaso Formation, stream-deposited sandstone of the Galisteo Formation, and limestone- to granite-bearing sandstone and conglomerate near Bishops Lodge
Pzu	Paleozoic rocks	Limestone, siltstone, shale, and sandstone
XYu	Proterozoic rocks	Granite, pegmatite, and amphibolite of the southern Sangre de Cristo Mountains

*Unit known to host either shallow or deep aquifers.









Geologic Units

Not shown on or different from Figure 4-1

Ttce	Cejita Member, Chamita and Tesuque Formations
Ttc	Chama-El Rito Member, Tesuque Formation
Ttsc	Lithosome S of the Tesuque Fm (coarse-grained)
Ttsm	Lithosome S of the Tesuque Fm (medium-grained)
Ttc	Lithosome S of the Tesuque Fm (fine-grained)

Other Symbols

Fault

City of Santa Fe well

Figure 4-2 Geologic cross sections through the Buckman and City well fields, showing key hydrostratigraphic units. The Tesuque Formation hosts the regional aquifer tapped by Santa Fe's water-supply wells but its lithology varies from place to place (e.g., coarse- versus fine-grained sub-units).

4.1.2 Climate and Hydrology

The average annual temperature for the City of Santa Fe over the years 1981-2010 is 51°F with highs reaching into the mid-90s and lows in the mid-teens (WRCC 2020). The average annual precipitation in the City is 14.2 inches, most of which occurs as summer monsoon rainfall during late June to September. The Köppen-Geiger climate classification, a commonly used climate index, places Santa Fe in class *Bsk* indicating a semi-arid, steppe-like climate with cold winters.

4.1.3 Land Use and Population

The City of Santa Fe was established in 1610 and has served as New Mexico's capital since that time. In addition to its status as an administrative seat, the city has long been a center for agrarian, commercial, intellectual, and tourism activities in north-central New Mexico and land use in the Santa Fe area has evolved dramatically over time.

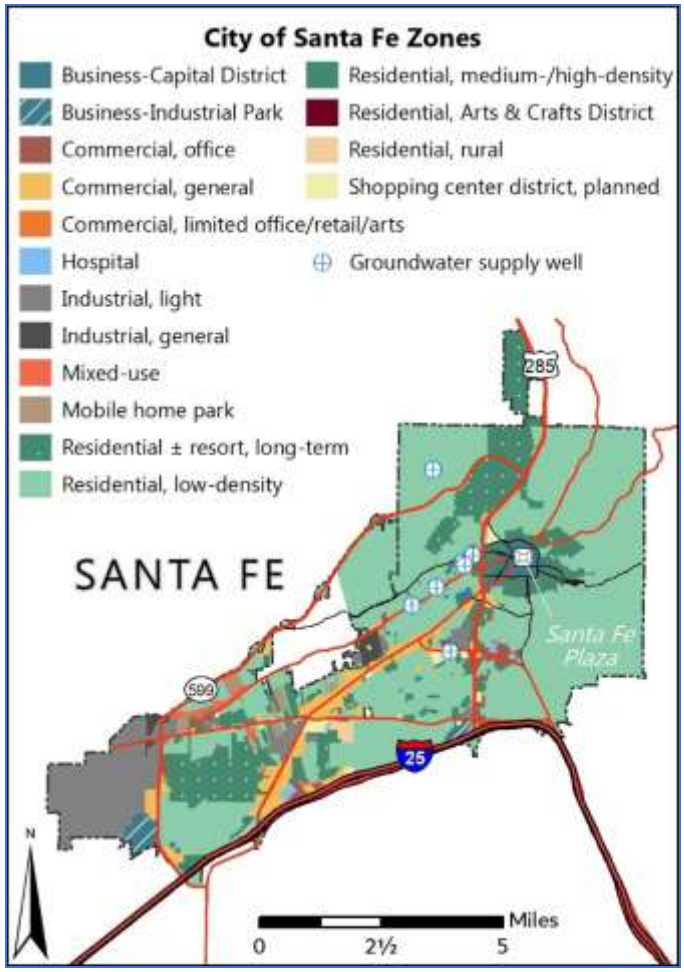


Figure 4-3 Zone types within the City of Santa Fe showing locations of water supply wells in the City Well Field. Note that residential zones are grouped together based on intended density and urban form.

Today, Santa Fe is the fourth largest city in the state with an estimated 2019 population of 84,683 (USCB 2020). The area is mostly urbanized though vestiges of the city's past abound in the form of historic architecture and an acequia system more than 400 years old. Over 50% of the city is zoned for residential use with another 27% for commercial, office, and retail and about 5% for industrial uses (Figure 4-3). The seven active supply wells of the City Well Field are located in single- or multiple-family zones, except for St. Michaels Well which is located in a general commercial district.

Older homes and businesses in Santa Fe produced water from hand-dug wells that were typically 15 to 40 ft deep. These wells depended on surface recharge to the shallow aquifer, which declined over time due to the transfer of water rights from surface to groundwater (Lazarus and Drakos 1995). Dwindling flows in unlined acequias, decreasing flood irrigation, and extensive paving of surface across the City led to most shallow wells drying up after the mid-1960s.

Pumping of the City wells caused groundwater levels to fall as much as 180 feet from 1951 to the mid-1990s as well as cones of depression (drawdown) surrounding the well field (Lazarus and Drakos 1995). A reduction in pumping since 2011 and increases in Santa Fe River flows have helped lessen drawdown, although cones of depression are still apparent in spatial groundwater-level patterns, particularly around St. Michaels Well (JSAI 2019).

4.2 Source Water Protection Area: Buckman Well Field

4.2.1 *Physical Geography and Geology*

The Buckman Well Field consists of 13 wells in an area of about 12 mi^2 located 8-15 miles northwest of Santa Fe. Nine Buckman wells (1-8 and 3A; Table 3.1) were drilled in the 1970s to 1990s on the east side of the Rio Grande directly across from the town of White Rock. Buckman Wells 9-13 were drilled in the early 2000s.

Like the City Well Field, the Buckman wells rely on a regional aquifer hosted by the Tesuque Formation of the Santa Fe Group. A key difference is that the Tesuque Formation at Buckman Wells 1-9 and 3A consists of sediments deposited in a greater diversity of environments, including distal piedmont (far from the mountain front), fluvial (river deposits of the ancestral Rio Grande), and basin floor (Figure 4-1; Koning et al. 2007). There is considerably more interfingering of sediments ranging from sand- and gravel-dominated to more impermeable muds and clay (Figure 4-2).

Buckman Wells 1-8 and 3A are screened across permeable sands and gravels of the ancestral Rio Grande, whereas Well 9 is screened across finer-grained deposits and exhibits lower yield as a result (Koning et al. 2007). Artesian conditions at Wells 1-9 result from westward flow down the dip of west-northwest-tilted beds in the Tesuque Formation and deep groundwater flow that rises along fault zones (JSAI 2012).

Buckman Wells 10-13 penetrate deposits of similar grain size as Wells 1-8 but belonging to the same ancestral Santa Fe River lithosome as the Tesuque Formation sediments penetrated by the City Well Field. These wells were drilled under artesian conditions that no longer exist as suggested by flattening hydraulic gradients (JSAI 2020).

4.2.2 *Land Use*

The original portion of the Buckman Well Field (Wells 1-9, 3A) is located at and around the former settlement of Buckman, a station on the narrow-gauge Denver and Rio Grande railroad (Julyan 1998). Buckman was abandoned in the early 20th century and today the Buckman wells are located on U.S. Bureau of Land Management (BLM) or Forest Service land. Wells 1-9 and 3A are sited between the BLM Diablo Canyon Recreation Area to the south and the Rio Grande to the northwest. Scenes from several modern western movies have been filmed at the recreation area.

4.3 Source Water Protection Area: Upper Santa Fe River Watershed

4.3.1 *Physical Geography and Geology*

The Santa Fe River watershed covers 245 mi^2 in north-central New Mexico, of which 27 mi^2 are located in the Upper Santa Fe River (USFR) sub-watershed above the former Two Mile Reservoir (Figure 4-4). The Santa Fe River flows approximately 44 miles from its headwaters at Santa Fe Lake in the Sangre de Cristo Mountains to the Rio Grande just below Cochiti Dam. The total relief (elevation difference) of the Santa Fe River watershed is 7,195 feet, and the relief of the USFR sub-watershed is 5,061 ft.

The Santa Fe River is located in the Rio Grande rift tectonic province, except for the USFR which originates in the Southern Rocky Mountains. The geology along its course is highly variable, from crystalline igneous rocks such as granite, gneiss, and quartz pegmatite in the southern Sangre de Cristo Mountains (Bauer et al. 1996) to basin-fill sediment of the Santa Fe Group, basaltic and andesitic lava

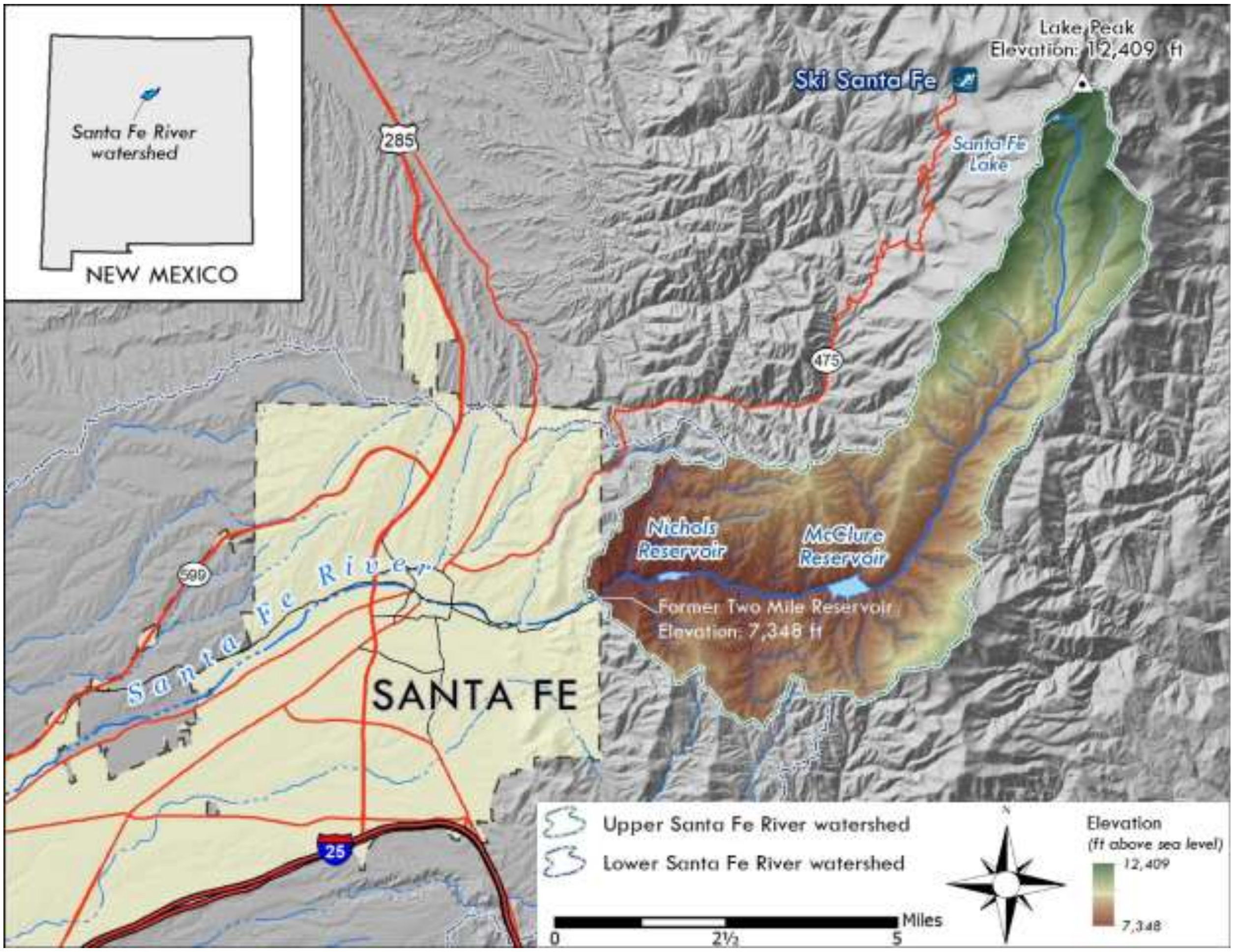


Figure 4-4 Digital shaded relief map of the Santa Fe River watershed in the vicinity of Santa Fe.

flows, and young alluvium below Two Mile Reservoir (Koning and Read 2010). Paleozoic limestone and sandstone crop out along a short reach of the river from Two Mile Reservoir to Arroyo Saiz.

Soils play a critical role in the hydrologic cycle because their properties affect the rates at which precipitation infiltrates into underlying aquifers or runoff travels laterally through the unsaturated zone or along the surface toward stream channels. A number of different soil units, distinguished by their physical characteristics such as depth, texture, and composition, are found in the USFR watershed but only a few are common. Steep, rocky slopes in the granitic terrain are dominated by soils of the Broadmoor family-Rock outcrop and Mirabal-Ashbray families Rock outcrop complexes (Soil Survey Staff 2020). These soil units are well-drained and characterized by their position on steep slopes (at least 15-25°) and gravelly composition.

Floodplains of the Santa Fe River and its tributaries in the USFR watershed are characterized by three soil complexes that cover a much smaller surface area than the Broadmoor-Mirabal-Ashbray-Rock outcrop complexes. These include the Morenda-Fiesta-Dula, Riomedio stony-Tricorner families, and Riomedio-Uwing complexes (Soil Survey Staff 2020). These units are somewhat poorly to well-drained and are found on flat ground to moderate slopes (0-35°). Their parent material is mixed stream alluvium and as a result their composition ranges from clayey or loamy to sandy or gravelly. The water table often lies no more than 1-3 ft below the surface of these valley-floor soils.

4.3.2 Climate and Hydrology

There are no climate stations in the USFR watershed with records comparable to those for the City of Santa Fe. However, the Gascon station (293488) in Mora County approximately 25 miles northeast of McClure Reservoir has a representative climate because it is located in the Sangre de Cristo Mountains at an elevation of 8,250 feet above sea level. The 1981-2010 average annual temperature at Gascon is 44° with highs in the high-70s to low-80s and lows in the mid-teens (WRCC 2020). The average annual precipitation at Gascon is 26 inches, much of which falls as summer monsoon rainfall but includes a greater amount of snowfall than lower-lying areas. The Köppen-Geiger climate classification places most of the USFR watershed in class *Dfb* indicating a cold, continental climate with cool summers and no distinct dry season (Beck et al. 2018).

The Santa Fe River crosses three hydrogeologic basins: a mountainous basin confined to relatively narrow canyon floors in the southern Sangre de Cristo range, the Española Basin from Santa Fe to La Bajada Hill, and the Santo Domingo Basin in its reach below La Bajada. The river flows perennially (year-round) in the mountainous USFR watershed but is ephemeral (flows only in response to runoff from precipitation) in its lower reaches (Figure 4-5). However, the City holds a discharge permit at its wastewater treatment plant near Santa Fe Regional Airport and the Santa Fe River flows downstream to La Bajada for part of the year as a result. Discharge (flow) data for the Santa Fe River is shown in Table 4-2.

Table 4-2 Select USGS stream gages and flow statistics on the Santa Fe River listed upstream to downstream

Gage Name USGS No.	Period of Record[1]	Max Discharge (cfs) (Year)	Min Discharge (cfs) (Year)	Mean Discharge (cfs)	Mean Discharge (cfs) 2010-2019
Above McClure Reservoir (8 ft flume) 08315480[2]	7/1998 – 10/2020	199 (2013)	0.05 (2002)	5.59	5.48
Above McClure Reservoir (1.5 ft flume) 08315479[2]	9/2001 – 9/2007	16.5 (2004)	0 (mult)	1.55	--
Near Santa Fe (*between McClure and Nichols*) 08316000	2/1913 – 10/2020	378 (1929)	0 (mult)	7.81	5.84
Above Cochiti Lake 08317200	3/1970 – 10/2020	1000 (1992)	0 (mult)	9.35	4.91

[1]All gages have period of record gaps of varying duration.
[2]The flumes above McClure Reservoir were replaced with a Replogle flume (broad-crested weir) in 2012. Measured flows before and after 2012 may not be directly comparable.

A changing climate may hold potentially serious consequences for dependable flow in the Santa Fe River watershed and other basins of the Southwest. Stream flows above McClure Reservoir have been projected to decrease by 11-18% of their 1950-1999 levels by the year 2060 (Cox et al. 2011). Decreased snowpack and earlier spring runoff along with increased drought and wildfire frequency are all possible effects of climate change that can impact the quality and quantity of surface water flows, even if scenarios of lower greenhouse gas emissions are achieved (Figure 4-6).

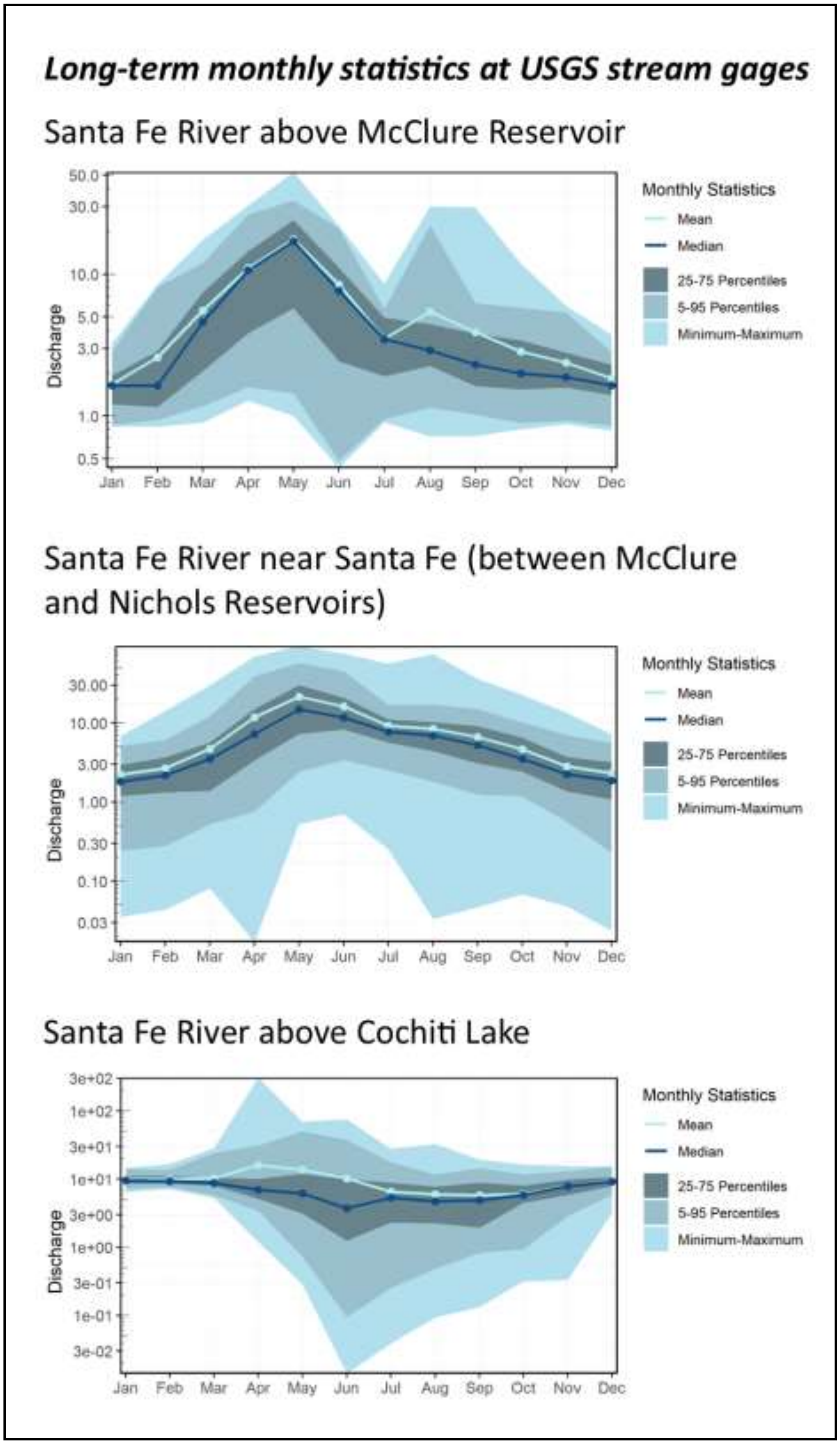


Figure 4-5 Monthly statistics for flow on the Santa Fe River at three stream gages (period of record; see Table 4-2). Discharge is in cubic feet per second (cfs).

4.3.3 Land Use

The USFR watershed is located in the Santa Fe National Forest but is closed to the public to protect the Santa Fe River source waters. The upper 10,000 acres of the watershed are located in the Pecos Wilderness Area.

Archeological sites and historic properties in the USFR watershed suggest that people have used the Santa Fe River and its environs since prehistoric times (Duran and Thomas 2020). Homesteaders, ranchers, and farmers visited and lived in the area during the 17th and 18th centuries raising livestock, cutting timber, and acquiring water from the Santa Fe River. Small check dams constructed for watering livestock are found in certain high drainages such as the sub-catchment directly to the north of McClure Reservoir.

Significant development of the USFR watershed began in the late 1800s with the establishment of labor camps for prisoners of the New

Figure 4-6 Historical and projected average daily maximum temperatures in Santa Fe based on low- and high-emission scenarios. Data from NOAA ClimateExplorer.

Mexico Territorial Penitentiary (Torrez 2004). A ranger station operated in the lower canyon during the early 1900s and the High Line Ditch was constructed to transmit water from below the location of modern-day Nichols Reservoir to Santa Fe's first hydroelectric power plant built in 1895 on Canyon Road. The USFR has been closed to unauthorized access since 1932 to protect the City's water supply (Figure 4-7; USDA 2001).

Figure 4-7 The upper Santa Fe River watershed has been closed to public access since 1932.

The City of Santa Fe has partnered with the U.S. Forest Service and the New Mexico Finance Authority Water Trust Board since the early 2000s to conduct wildfire mitigation projects in the USFR watershed. In 2001, approximately 7,300 acres of dense ponderosa pine forest were thinned and treated with prescribed burns in the vicinity of the City's active water supply reservoirs (Lewis 2018). An additional 5,500 acres were treated in the non-wilderness portion of the USFR between 2003 and 2009 (Margolis et al.

2013). Prescribed burns have been proposed for ponderosa and mixed conifer forests in the Pecos Wilderness portion of the USFR watershed above McClure Reservoir (USDA 2014), but this work has yet to occur. Fire mitigation is further discussed in Section 6.4.

5.0 SOURCE WATER ASSESSMENT: INVENTORY OF POTENTIAL CONTAMINANT SOURCES AND OTHER THREATS

5.1 Overview of Potential Contaminant Sources and Risk Assessment

Potential sources of contamination (PSOCs) are defined as any possible site or event that could, under any circumstance and time frame, lead to contamination of drinking water sources. Not all sites identified as PSOCs pose the same level of risk. Depending on the type of PSOC, some sites may pose little to no contamination risk, while others may pose an imminent threat. Sources of contamination (SOCs) are considered those activities or environmental accidents that are currently threatening or contaminating the source water.

Source water protection areas (SWPA) were delineated based on the best available data. Hydrogeologic modeling for the City Well Field allowed for SWPAs based on 15- and 35-year capture zones, i.e. geographic areas over which a single particle of groundwater travels over the given timeframe to the well (CDM 1992; JSAI unpublished data). Such modeling was not available for the Buckman Well Field and fixed radii (0-200 ft, 201-500 ft, 501-1000 ft, and 1001-5280 ft) were used instead. Finally, the Upper Santa Fe River SWPA is considered to be the entire USFR watershed because moderate to severe wildfires could generate sediment and other contaminants reaching the river from all portions of its catchment.

Following the identification of PSOCs and SOCs in the City's SWPAs, a risk assessment was performed for each contaminant. This methodology is based on a technique developed by the Colorado Rural Water Association (e.g., CRWA 2017) and involves estimation of risk using two parameters:

1. **Probability of Impact** – The risk to source waters increases as the relative probability of damage or loss increases. The probability of impact is determined by evaluating the number of contaminant sources, the migration potential or proximity to the water source, and the historical data. The following descriptions provide a framework to estimate the relative probability that damage or loss would occur within one to ten years.

Certain: >95% probability of impact
Likely: >70% to <95% probability of impact
Possible: >30% to <70% probability of impact
Unlikely: >5% to <30% probability of impact
Rare: <5% probability of impact

2. **Impact to the Public Water System** – The risk to source waters increases as the impact to the water system increases. The impact is determined by evaluating the human health concerns and potential volume of the contaminant source. The following descriptions provide a framework to estimate the impact to the public water system:

Catastrophic: Irreversible damage to the water source(s). This could include the need for new treatment technologies and/or the replacement of existing water source(s).

Major: Substantial damage to the water source(s). This could include a loss of use for an extended period of time and/or the need for new treatment technologies.

Significant: Moderate damage to the water source(s). This could include a loss of use for an extended period of time and/or the need for increased monitoring and/or maintenance activities.

Minor: Minor damage resulting in minimal, recoverable, or localized efforts. This could include temporarily shutting off an intake or well and/or the issuance of a boil order.

Insignificant: Damage that may be too small or unimportant to be worth consideration but may need to be observed for worsening conditions. This could include the development of administrative procedures to maintain awareness of changing conditions.

The probability of impact and impact to the public water system parameters are then combined in a risk assessment matrix to qualify the risk of a given contaminant (Figure 5-1).

Probability of Impact					
Certain	**Low**	**Moderate**	**High**	**Very High**	**Very High**
Likely	**Low**	**Moderate**	**High**	**High**	**Very High**
Possible	**Low**	**Moderate**	**Moderate**	**High**	**High**
Unlikely	**Very Low**	**Low**	**Moderate**	**Moderate**	**Moderate**
Rare	**Very Low**	**Very Low**	**Low**	**Low**	**Low**
	Insignificant	Minor	Significant	Major	Catastrophic

Impact to Water System

Figure 5-1 Risk assessment matrix used for City of Santa Fe PSOCs and SOCs (after the Colorado Rural Water Association's Source Water Assessment and Protection Program).

Locations of SOCs and PSOCs for the City of Santa Fe Water System are found on the following source water protection area maps for the Buckman and City well fields (Figures 5-2 and 5-3). A full list of SOCs and PSOCs for the City and Buckman wells and assigned risk levels are found in Tables 5-1 and 5-2. The "Control" column refers to the level of control that the City has over a given PSOC or SOC, including regulatory controls in conjunction with NMED.

Wildfire-related impacts are considered to be the greatest threat to the Upper Santa Fe River watershed and potential debris-flow and contamination hazards are shown at the sub-catchment scale in Figure 5-4.

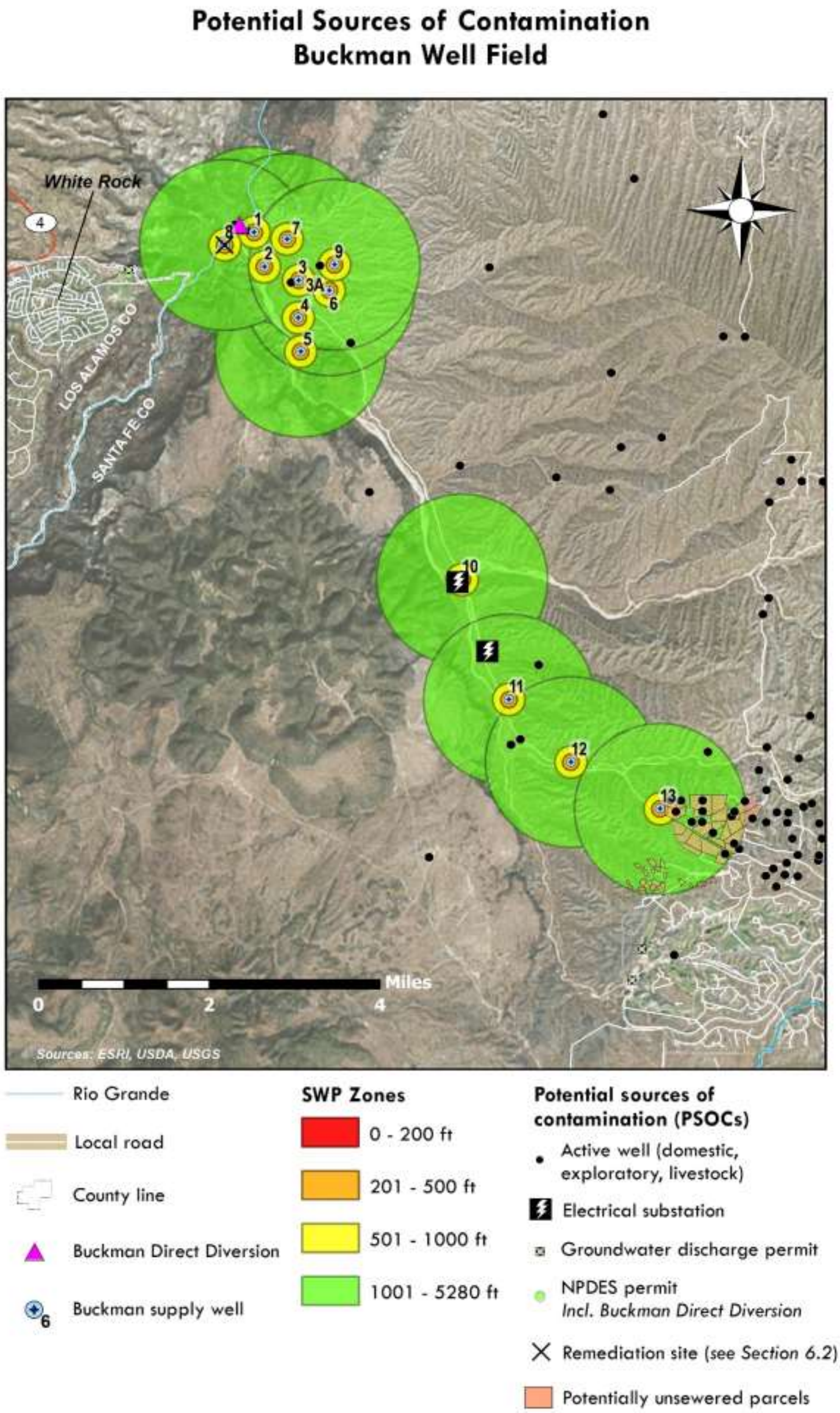


Figure 5-2 Source water protection areas and PSOCs for the Buckman Well Field.

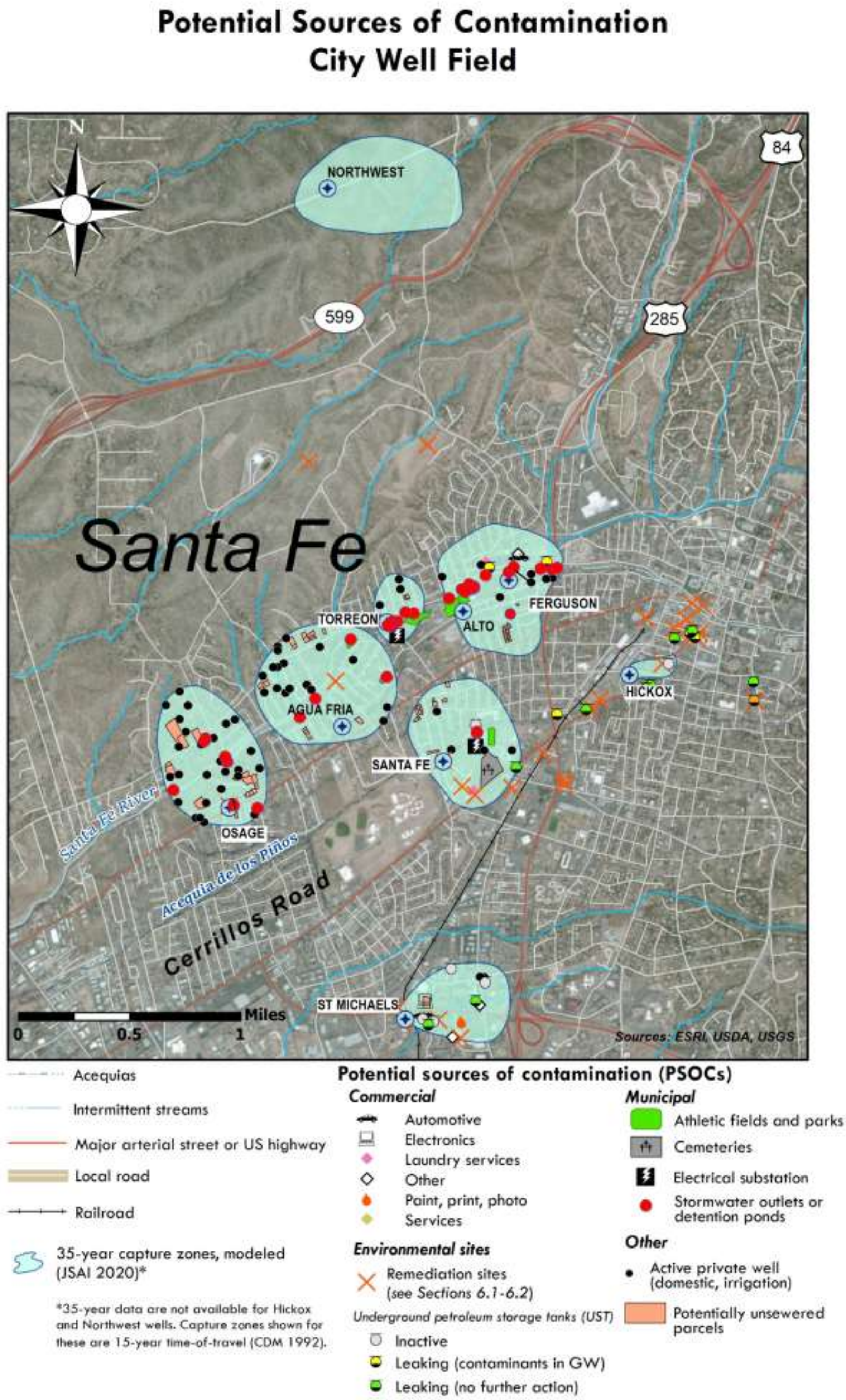


Figure 5-3 Source water protection areas and PSOCs for the City Well Field.

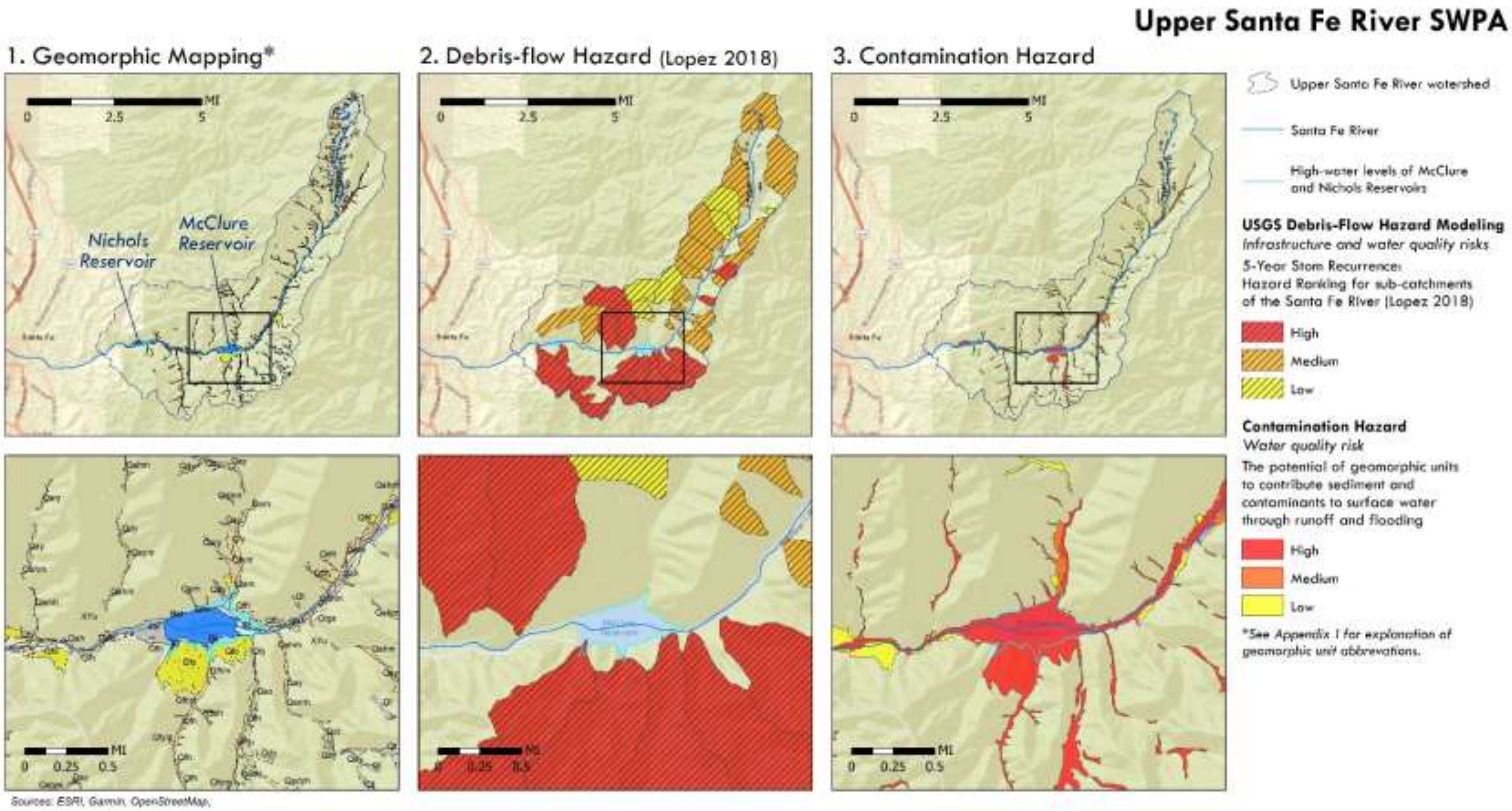


Figure 5-4 Source water protection area and hazards for the Upper Santa Fe River. PSOCs in the watershed include excess sedimentation, ash, and trace metals generated during runoff and debris flows following potential stand-replacing wildfires.

Table 5-1 Contaminant source inventory for the City Well Field. See Figure 5-1 for risk assessment criteria

Well	PSOC Type	PSOC Description	#	Actual (A) or Potential (P) Contamination	Probability of Impact	Impact to PWS	Risk	Control	Explanation
City Well Field									
Agua Fria	Abatement site	Used oil spill	1	A	Possible	Insignificant	Low	Direct	Closed
	Arroyos	—	3	P	Unlikely	Minor	Low	Direct/Indirect	City operates upper Santa Fe River dams
	Dirt roads	—	9	P	Unlikely	Minor	Low	Indirect	
	MSD	Storm drainage collection areas or outlets (unlined)	4	P	Unlikely	Minor	Low	Indirect	City manages stormwater system
	Parks / Athletic Fields	—	1	P	Rare	Insignificant	Very Low	Direct	
	PDW	Private domestic wells	18	P	Rare	Minor	Very Low	None	
	Primary roads	—	1	P	Likely	Minor	Moderate	Indirect	
	RSF	Single family residences, unsewered	19	P	Rare	Minor	Very Low	Indirect	Sewered/unsewered status unconfirmed
Alto-Ferguson[1]	Arroyos	—	3	P	Unlikely	Minor	Low	Direct/Indirect	City operates upper Santa Fe River dams
	CAR	Automotive repair shops	1	P	Rare	Minor	Very Low	Indirect	
	CFB/CSS	Leaking underground storage tank (LUST) site	3	A	Certain	Minor	Moderate	None	Cleanups at Alto Park, Exxon W Alameda, and NewMexigas LUSTs. Contaminants now below water quality standards
	CCW	Car washes	1	P	Possible	Minor	Moderate	Indirect	
	Dirt roads	—	4	P	Unlikely	Minor	Low	Indirect	
	Laundromat	—	1	P	Rare	Significant	Low	Indirect	
	MSD	Storm drainage collection areas or outlets (unlined)	13	P	Unlikely	Minor	Low	Indirect	City manages stormwater system
	Parks / Athletic Fields	—	2	P	Rare	Insignificant	Very Low	Direct	
	PDW	Private domestic wells	7	P	Rare	Minor	Very Low	None	
	Primary roads	—	2	P	Likely	Minor	Moderate	Indirect	
	RSF	Single family residences, unsewered	18	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed
Hickox[2]	Abatement site	Used oil LUST site (Garcia Honda)	1	A	Possible	Insignificant	Low	None	Closed
	CFB	Underground storage tanks	1	P	Unlikely	Minor	Low	None	
	Primary roads	—	2	P	Likely	Minor	Moderate	Indirect	
Northwest[2]	Arroyos	—	1	P	Unlikely	Insignificant	Very Low	Indirect	
	Dirt roads	—	7	P	Unlikely	Minor	Low	Indirect	
Osage	Abatement site	Osage Well	1	A	Certain	Insignificant	Low	Direct	Closed
	ADC	Irrigation wells	4	P	Rare	Minor	Very Low	None	
	Arroyos	—	2	P	Unlikely	Minor	Low	Direct/Indirect	City operates upper Santa Fe River dams
	Dirt roads	—	13	P	Unlikely	Minor	Low	Indirect	
	MSD	Storm drainage collection areas or outlets (unlined)	7	P	Unlikely	Minor	Low	Indirect	City manages stormwater system
	PDW	Private domestic wells	25	P	Rare	Minor	Very Low	None	
	Primary roads	—	1	P	Likely	Minor	Moderate	Indirect	
	RSF	Single family residences, unsewered	17	P	Rare	Minor	Very Low	Indirect	Sewered/unsewered status unconfirmed
Santa Fe	Abatement site	Berridge Distributing Co	1	A	Possible	Insignificant	Low	Direct	Closed
	Abatement site	PNM Santa Fe Generating Station	1	A	Certain	Major	Very High	Direct	
	ADC	Drainage canals, ditches or acequias (unlined)	1	P	Rare	Minor	Very Low	Indirect	
	ADC	Irrigation wells	2	P	Rare	Minor	Very Low	None	
	CCE	Cemeteries	1	P	Unlikely	Minor	Low	Indirect	
	CFB/CSS	Leaking underground storage tank (LUST) site	1	A	Possible	Insignificant	Low	None	
	CST	Commercial septic tanks/leachfields/leachpits/cesspools	1	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed
	Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	

	Electrical substation	—	1	P	Unlikely	Minor	Low	Indirect	
	Laundromat	—	1	P	Rare	Significant	Low	Indirect	
	MSD	Storm drainage collection areas or outlets (unlined)	2	P	Unlikely	Minor	Low	Indirect	City manages stormwater system
	Parks / Athletic Fields	—	1	P	Rare	Insignificant	Very Low	Direct	
	PDW	Private domestic wells	2	P	Rare	Minor	Very Low	None	
	Primary roads	—	1	P	Likely	Minor	Moderate	Indirect	
	RSF	Single family residences, unsewered	14	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed
St. Michaels	Abatement site	Park Avenue Cleaners	1	A	Possible	Insignificant	Low	Indirect	
	Abatement site	Premier Nissan	1	A	Possible	Insignificant	Low	Indirect	Closed
	Abatement site	Smith’s #491 Fuel Center	1	A	Possible	Insignificant	Low	Indirect	Closed
	ADC	Drainage canals, ditches or acequias (unlined)	1	P	Rare	Minor	Very Low	Indirect	
	Arroyos	—	1	P	Rare	Minor	Very Low	Indirect	
	CAR	Automotive repair shops	2	P	Unlikely	Significant	Moderate	Indirect	
	CCW	Car wash	1	P	Possible	Minor	Moderate	Indirect	
	CDC	Dry cleaning shop	1	A	Certain	Minor	Moderate	Indirect	
	CFB	Underground storage tanks	4	P	Unlikely	Minor	Low	Indirect	
	CFB/CSS	Leaking underground storage tank (LUST) site	2	A	Possible	Insignificant	Low	None	
	CRY	Railroad yards and tracks	1	P	Possible	Major	High	None	
	CST	Commercial septic tanks/leachfields/leachpits/cesspools	1	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed
	CVS	Veterinary facilities	1	P	Rare	Insignificant	Very Low	Indirect	
	CPR	Printing shops	2	P	Rare	Minor	Very Low	Indirect	
	PDW	Private domestic wells	2	P	Rare	Minor	Very Low	None	
	Primary roads	—	1	P	Likely	Minor	Moderate	Indirect	
Torreon	Arroyos	—	1	P	Unlikely	Minor	Low	Direct/Indirect	City operates upper Santa Fe River dams
	Electrical substation	—	1	P	Unlikely	Minor	Low	Indirect	
	MSD	Storm drainage collection areas or outlets (unlined)	8	P	Unlikely	Minor	Low	Indirect	City manages stormwater system
	Parks / Athletic Fields	—	1	P	Unlikely	Insignificant	Very Low	Direct	
	PDW	Private domestic wells	4	P	Rare	Minor	Very Low	None	
	RSF	Single family residences, unsewered	3	P	Rare	Minor	Very Low	Indirect	Sewered/unsewered status unconfirmed

[1]35-year capture zones for Alto and Ferguson overlap and are therefore treated as one zone.
[2]The Hickox and Northwestern wells were not modeled by JSAI. PSOCs are for 15-year capture zones developed by Camp, Dresser, and McKee (CDM 1992).

Table 5-2 Contaminant source inventory for the Buckman Well Field. See Figure 5-1 for risk assessment criteria

Well	SWP Zone	PSOC Type	PSOC Description	#	Actual (A) or Potential (P) Contamination	Probability of Impact	Impact to PWS	Risk	Control	Explanation
Buckman Well Field										
Well 1	A-D	Arsenic	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Arsenic above MCL of 10 µg/L in 2011
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	3	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
	D	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	5	P	Unlikely	Minor	Low	None	
		Dirt roads	—	2	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	6	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
Well 2	A-D	Uranium	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Uranium above MCL of 30 µg/L in 2011
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	6	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	6	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
Well 3	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
	D	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	11	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	6	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 4	A	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	

	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	7	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 5	A	Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	B	Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	C	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	Arroyos	—	5	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 6	B	Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	C	Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	8	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 7	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
	D	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	8	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	6	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
Well 8	A	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
	B	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		Arroyos	—	1	P	Unlikely	Minor	Low	None	
	C	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		Arroyos	—	1	P	Unlikely	Minor	Low	None	
	D	Abatement site	Buckman Well 8 transformer spill	1	A	Possible	Insignificant	Low	Direct	Closed
		Arroyos	—	7	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply wells (incl. exploratory)	6	P	Rare	Minor	Very Low	Direct	
		NPDES permit	Buckman Direct Diversion	1	P	Unlikely	Significant	Moderate	Indirect	
Well 9	A-D	Arsenic	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Arsenic above MCL of 10 µg/L in 2011
	A	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	C	ADC	Stock well	1	P	Rare	Minor	Very Low	None	

		Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	ADC	Stock well	1	P	Rare	Minor	Very Low	None	
		Arroyos	—	8	P	Unlikely	Minor	Low	None	
		Dirt roads	—	3	P	Unlikely	Minor	Low	Indirect	
		MWP	Water supply well (incl. exploratory)	1	P	Rare	Minor	Very Low	Direct	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 10	A	Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	B	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		Electrical substation	—	1	P	Unlikely	Minor	Low	Indirect	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		Electrical substation	—	1	P	Unlikely	Minor	Low	Indirect	
	D	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	2	P	Unlikely	Minor	Low	Indirect	
		Electrical substations	—	2	P	Unlikely	Minor	Low	Indirect	
Well 11	A-D	Arsenic	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Arsenic above MCL of 10 µg/L in 2011
	A	Arroyos	—	1	P	Unlikely	Minor	Low	None	
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	C	Arroyos	—	2	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	ADC	Stock wells	3	P	Rare	Minor	Very Low	None	
		Arroyos	—	4	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		Electrical substation	—	1	P	Unlikely	Minor	Low	Indirect	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
Well 12	A-D	Arsenic	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Arsenic above MCL of 10 µg/L in 2011
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	C	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	D	ADC	Stock wells	3	P	Rare	Minor	Very Low	None	
		Arroyos	—	5	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
Well 13	A-D	Arsenic	Naturally occurring contaminant	1	A	Certain	Significant	High	None	Arsenic above MCL of 10 µg/L in 2011
	A	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
	B	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		RSF	Single family residences, unsewered	2	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed
	C	Arroyos	—	1	P	Unlikely	Minor	Low	None	
		Dirt roads	—	1	P	Unlikely	Minor	Low	Indirect	
		PDW	Private domestic well	1	P	Rare	Minor	Very Low	None	
		RSF	Single family residences, unsewered	2	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed

	D	Arroyos	—	3	P	Unlikely	Minor	Low	None	
		Dirt roads	—	7	P	Unlikely	Minor	Low	Indirect	
		PDW	Private domestic wells	15	P	Rare	Minor	Very Low	None	
		RSF	Single family residences, unsewered	45	P	Rare	Insignificant	Very Low	Indirect	Sewered/unsewered status unconfirmed

6.0 Managing for Source Water Protection

This section of the Source Water Protection Plan considers the issues of concern and recommended actions and protection strategies. The potential and actual contamination sources listed in Tables 5-1 and 5-2 are summarized below along with current remediation efforts and strategies to mitigate or prevent additional contamination.

6.1 Known Sources of Contamination to Source Water Supplies

PNM Santa Fe Generating Station	
Risk Assessment	Very High ▲
Sources Affected	• Santa Fe, Agua Fria (?)
Contaminants of Concern	• Volatile organic compounds (VOCs) • Synthetic organic compounds (SOCs) • Chlorinated solvents • Polycyclic aromatic hydrocarbons (PAHs) • Nitrate

Issues

The Santa Fe Well was drilled in 1951 by the Sangre de Cristo Water Company, a subsidiary of the Public Service Company of New Mexico (PNM), and served as one of the City's primary water supply wells until contaminants were detected in 1988. The well has been inactive since 2013.

- Two known on-site releases: chlorinated VOCs east of PNM service center and 84,000 gallons of fuel oil spilled in 1952 (Metric 1995)
- Initial detection of dissolved-phase benzene, 1,2-dibromoethane (EDB), 1,2-dichloroethane (EDC), and xylenes in the Santa Fe Well, October 1988
- 25 active monitoring wells installed in the site area west of New Mexico School for the Deaf
- Four distinct contamination plumes in the perched aquifer covering at least 20 acres
- *2018-2020 chemicals exceeding maximum contaminant levels (MCLs) under EPA National Primary Drinking Water Regulations (INTERA 2020):*
  - Benzene: up to 5,700 µg/L in monitoring well USTB-27 (MCL = 5 µg/L)
  - Toluene: up to 9,400 µg/L in monitoring well USTB-35 (MCL = 1,000 µg/L)
  - Ethylbenzene: up to 1,500 µg/L in monitoring well USTB-35 (MCL = 700 µg/L)
  - Total xylenes: up to 5,100 µg/L in monitoring well USTB-35 (MCL = 620 µg/L)*
  - EDB: up to 28 µg/L in monitoring well USTB-38 (MCL = 0.05 µg/L)
  - EDC: up to 150 µg/L in monitoring well USTB-27 (MCL = 5 µg/L)
  - Total naphthalenes: up to 960 µg/L in monitoring well USTB-35 (MCL = 30 µg/L)*
  - 1,1-dichloroethylene: up to 54 µg/L in monitoring well USTB-32 (MCL = 7 µg/L)
  - Carbon tetrachloride: up to 11 µg/L in monitoring well USTB-32 (MCL = 5 µg/L)
  - Tetrachloroethylene (PCE): up to 9.9 µg/L in monitoring well USTB-22 (MCL = 5 µg/L)
  - Trichloroethylene (TCE): up to 17 µg/L in monitoring well USTB-35 (MCL = 0.05 µg/L)
  - Nitrate: up to 79 mg/L in former bionutrient injection well OS-15 (MCL = 10 mg/L)
- Past bioremediation treatment proved ineffective (1998-2002)

Concerns • Known contamination of the shallow aquifer at and surrounding the Santa Fe Well • Benzene and 10 other compounds exceeded New Mexico Water Quality Control Commission (NMWQCC) standards in 2018-2020 sampling of nearby monitoring wells • Potential plume migration toward Agua Fria Well but poorly characterized • Contributions from poorly characterized sources off-site - For example, the local hydrogeology suggests that the former generating station was not the source of light non-aqueous phase liquid (LNAPL) product containing EDB or PCE (Hawley 2016)
Strategies • Ongoing groundwater monitoring events, including sampling associated with NMED Groundwater Quality Bureau Stage I Abatement Plan and NMED Petroleum Storage Tank Bureau Corrective Action Fund (CAF) Work Plan • Coordination with the NMED Ground Water Quality and Petroleum Storage Tank Bureaus to be notified when investigation of the site has produced a report • Installation of additional monitoring wells for better delineation of dissolved-phase contaminant plume(s) • Evaluation and development of remediation actions at highly contaminated wells northeast of the Santa Fe Well (e.g., USTB-35)

*New Mexico Water Quality Control Commission (NMWQCC) standard (20.6.2.3103 NMAC). NMWQCC standards generally match EPA drinking water MCLs with some exceptions.

6.2 Known Sources of Contamination – Uncertain Impact to Source Water Supplies

Active Abatement Sites within SWPAs — *Park Avenue Cleaners*	
Risk Assessment	Low ▲
Sources Affected	St. Michaels (?)
Contaminants of Concern	• Tetrachloroethylene (PCE)
Concerns • Chlorinated solvent(s) from dry cleaning operations were found in sub-slab soils • Groundwater has not yet been monitored at the site	
Strategies • Active project under NMED Voluntary Remediation Program (VRP) • Coordination with the NMED Ground Water Quality Bureau to be notified when investigation of the site has produced a report • Groundwater monitoring is needed to characterize vertical and horizontal extent of contaminant(s)	

Closed Abatement Sites within SWPAs — *Garcia Honda, Osage Well, Premier Nissan, Santa Fe River Assessment, Smith's Fuel Center, transformer spill (Buckman Well 8), used oil spill (Agua Fria SWPA)*	
Risk Assessment	Low ▲

Sources Affected	• Agua Fria, Alto-Ferguson, Buckman Wells 8, Hickox, Osage, Santa Fe, St. Michaels (*impacts to regional aquifer generally not well-constrained or negligible)*
Contaminants of Concern	• Volatile organic compounds (VOCs) • Synthetic organic compounds (SOCs) • Chlorinated solvents • Nitrate

Issues

Former abatement sites where contaminant releases were confirmed and subsequently addressed are found within most of the City Well Field SWPAs and one Buckman Well Field SWPA. Groundwater flow paths and the vertical and horizontal extents of contamination plumes were not established at all of these sites nor was the overall threat to the City's groundwater supplies.

Many of the abatement sites attained closure in the 1990s and little background information is available as a result of their age. However, their closed status – as determined by the NMED State Cleanup, Targeted Brownfields Assessment, or Voluntary Remediation programs – indicates that each site was judged to be of low or insignificant risk to human health, safety, and the environment.

• Alto-Ferguson and Hickox SWPAs
  - Santa Fe River Assessment: petroleum hydrocarbons and chlorinated solvents throughout several hundred acres bordering the Santa Fe River

• Buckman Wells 1-3 and 7-8 SWPAs
  - These wells share overlapping SWPAs
  - Transformer 100-gallon spill in 1990, closed in 2000
  - Site was located within Buckman Well 8 SWPA Zones A-D; Zone D only of all other wells

• Hickox SWPA
  - Garcia Honda: used oil LUST site discovered in 1989, closed in 1990

• Osage SWPA
  - June 1995 soil sample at Osage Well returned <100 mg/L TPH*

• St. Michaels SWPA
  - Premier Nissan: petroleum hydrocarbon contaminants in soil and groundwater associated with releases from hydraulic lifts and a wash bay sump (NMED 2006)
  - Smith's Fuel Center: BTEX, TPH-DRO, TPH-GRO, and TPH-ORO in soils below former locations of hydraulic lifts. No contamination discovered in groundwater (NMED 2015)*

Concerns (SWPA)

• Vertical seepage of contaminants from shallow to regional aquifers

Strategies

• Closure at many sites was attained following soil excavation and subsequent soil sampling showing contaminants below applicable standards
• The Santa Fe River Assessment site encompasses the active Santa Fe County Judicial Complex Voluntary Remediation Program site, which received a final remediation plan in 2020

*BTEX = benzene, toluene, ethylbenzene, and total xylenes; TPH = total petroleum hydrocarbons; DRO = diesel range organics; GRO = gasoline range organics; ORO = oil range organics.

<table>
<tr><th colspan="2">Active Abatement Sites within ½ mile of SWPAs — NMDOT Main Yard/GOC, One Hour Martinizing (WIRTCO), Ortiz landfill (former), Santa Fe County Judicial Complex</th></tr>
<tr><td>Risk Assessment</td><td>N/A</td></tr>
<tr><td>Sources Affected</td><td>Alto-Ferguson, Hickox, Santa Fe (impacts to regional aquifer generally not well-constrained)</td></tr>
<tr><td>Contaminants of Concern</td><td>• Nitrate
• Tetrachloroethylene (PCE)
• Trichloroethylene (TCE)
• Volatile organic compounds (VOCs)</td></tr>
<tr><td colspan="2">Issues
Several sites with confirmed contaminant releases and ongoing remediation efforts are found within a half mile of City Well Field SWPAs. While local groundwater flow paths have been identified at these sites, the vertical and horizontal extents of contamination are not always known nor is the overall threat to the City’s groundwater supplies. Contamination of shallow aquifers in Quaternary sediments or the Ancha Formation has been confirmed at the Santa Fe Judicial Complex and WIRTCO sites, but potential impacts to the regional Tesuque Formation aquifer remain unknown.

• 2017-2019 chemicals exceeding MCLs at Santa Fe Judicial Complex (EA 2020):
- Benzene: up to 1,800 µg/L (MCL = 5 µg/L)
- Toluene: up to 13,000 µg/L (MCL = 1,000 µg/L)
- Ethylbenzene: up to 2,300 µg/L (MCL = 700 µg/L)
- Total xylenes: up to 17,000 µg/L (MCL = 620 µg/L)*
- EDB: up to 23 µg/L (MCL = 0.05 µg/L)
- EDC: up to 40 µg/L (MCL = 5 µg/L)
- Total naphthalenes: up to 4,700 µg/L (MCL = 30 µg/L)*
- Dissolved iron: up to 2.9 mg/L (MCL = 1 mg/L)*
- Dissolved manganese: up to 31 mg/L (MCL = 0.2 mg/L)*
- Nitrate: up to 36 mg/L (MCL = 10 mg/L)

• 2020 chemicals exceeding MCLs at WIRTCO (DBS&A unpublished data):
- Benzene: up to 69 µg/L (MCL = 5 µg/L)
- EDC: up to 12 µg/L (MCL = 5 µg/L)
- Total naphthalenes: up to 66 µg/L (MCL = 30 µg/L)*
- PCE: up to 30 µg/L (MCL = 5 µg/L)</td></tr>
<tr><td colspan="2">Concerns
• East to southeast groundwater gradient from former Ortiz landfill toward Alto-Ferguson wells
• NMDOT Main Yard/GOC and One Hour Martinizing (WIRTCO) have been identified as possible contributors to solvent contamination at the Santa Fe Generating Station site (Hawley 2016)
• Vertical seepage of contaminants from shallow to regional aquifers</td></tr>
<tr><td colspan="2">Strategies
• Active projects under NMED State Cleanup Program (SCP) or Voluntary Remediation Program (VRP)
• Environmental site assessment at WIRTCO (VRP)
• Final remediation plan (2020) at Santa Fe Judicial Complex (VRP)
• Site investigations at NMDOT Main Yard (SCP)
• Stage I Abatement Plan at Ortiz landfill (SCP)</td></tr>
</table>

- Investigation-derived wastes disposed according to NMED Hazardous Waste Bureau criteria
- Monitoring wells drilled to and screened across the regional Tesuque Formation aquifer are needed to characterize contaminant threats to the City's groundwater supplies
- Coordination with the NMED Ground Water Quality Bureau to be notified when investigation of active abatement sites has produced a report(s)

*New Mexico Water Quality Control Commission (NMWQCC) standard (20.6.2.3103 NMAC).

Closed Abatement Sites within ½ mile of SWPAs — *CAMPR Partners Ltd., Sanbusco Market Center, Santa Fe Railyard/Phillips Petroleum/La Unica Dry Cleaners*	
Risk Assessment	N/A
Sources Affected	• Alto-Ferguson, Hickox, Santa Fe (*impacts to regional aquifer generally not well-constrained)*
Contaminants of Concern	• Volatile organic compounds (VOCs) • Synthetic organic compounds (SOCs) • Chlorinated solvents • Metals • Radiogenic materials

Issues

Several former abatement sites where contaminant releases were confirmed and subsequently addressed are found within a half mile of (but outside) several City Well Field SWPAs. Groundwater flow paths and the vertical and horizontal extents of contamination plumes were not necessarily established at these sites nor was the overall threat to the City's groundwater supplies.

Background information for these sites varies depending on their age and complexity of cleanup operations. However, their closed status – as determined by the NMED State Cleanup, Targeted Brownfields Assessment, or Voluntary Remediation programs – indicates that each site was judged to be of low or insignificant risk to human health, safety, and the environment.

Concerns

- CAMPR Partners Ltd.:
  - Hydrocarbons in soils
- La Unica Dry Cleaners, former Phillips Petroleum (Catellus) bulk fuel terminal
  - Possible contributors to solvent and petroleum hydrocarbon contamination, respectively, at the Santa Fe Generating Station site (Hawley 2016)
- Sanbusco Market Center:
  - Petroleum hydrocarbon contaminants in soil and groundwater associated with releases from hydraulic fluids used in an elevator shaft (NMED 2001)
- Santa Fe Railyard:
  - Metals and petroleum hydrocarbons in soil
  - Former staging area for Atomic Energy Commission's Manhattan Project in the 1940s
- Vertical seepage of contaminants from shallow to regional aquifers

Strategies

- Closure at the CAMPR Partners Ltd. site was attained following soil excavation and subsequent soil sampling showing contaminants below applicable standards

Petroleum – Leaking Underground Storage Tanks (LUSTs)

Risk Assessment	Low to Moderate
Sources Affected	• Alto-Ferguson, Santa Fe, St. Michaels
Contaminants of Concern	• Volatile organic compounds (VOCs) such as benzene • Synthetic organic compounds (SOCs) such as ethylene dibromide (EDB)

Issues

Petroleum storage tanks (Figure 6-1) pose a risk to water systems when they are old and subject to leakage due to corrosion, failure of the piping systems, spills, and overfills, as well as equipment failure and operational error. Even a small release of petroleum to water supplies can have serious impacts. Only a few quarts of leaked gasoline can contaminate a drinking water supply well (USEPA 2001).

Figure 6-1 Underground storage tank (note worker at right for scale). Courtesy of NMED Petroleum Storage Tank Bureau.

Six leaking underground petroleum storage tanks (LUST) have been identified in several City SWPAs (not including former leaking tank locations at the Garcia Honda and Santa Fe Generating Station abatement sites). Four of these are resolved posing no further threat and one was still undergoing cleanup in 2020. The other site remains under investigation.

- Alto-Ferguson SWPA
  - Trace of amounts benzene, EDB, EDC, and toluene were detected in the Alto Well from the mid-1990s through May 2000 but have not been found since that time. The well was removed from service for additional monitoring during the period in which the contaminants were found
  - The Alto Park Well State Lead Facility LUST site was assessed for no further action by NMED in 2009
  - Dissolved-phase contamination is restricted to the immediate vicinity of the Exxon W Alameda LUST site
  - A monitoring well screened across the regional aquifer at the Exxon W Alameda LUST site showed no measured contaminants above their MCLs in September 2018 (DBSA 2018). The site remains under investigation
  - The New Mexigas LUST site was undergoing cleanup in 2020. Detailed site data is not yet available

- Santa Fe SWPA
  - The Cerrillos Self Serve 3 LUST site was assessed for no further action by NMED in 2013

- St. Michaels SWPA
  - The St. Mike's Shell and Allsups #252 LUST sites were assessed for no further action by NMED in 1994 and 2003, respectively

Concerns

- 10 additional LUSTs are located within one ½ mile of the City Well Field SWPAs (4 under investigation, 6 assessed for no further action)
- Vertical seepage of contaminants from shallow to regional aquifers

Strategies

- Coordination with the NMED Petroleum Storage Tank Bureau to be notified when investigations of LUST sites within the Alto-Ferguson SWPA has produced a report(s)
- NMED Petroleum Storage Tank Bureau regulations:
  - Secondary containment, overflow, and spill prevention systems must be tested every 3 years with monthly to annual inspection of these components and release detection systems
  - All facilities with fuel tanks should have an Operation and Maintenance Plan that includes a monthly inspection checklist
  - Suspected fuel releases must be reported to NMED Petroleum Storage Tank Bureau (PSTB) within 24 hours.
- Periodic review of groundwater reports from NMED PSTB for existing leaky underground storage tank sites

6.3 Potential Sources of Contamination – Well Fields

Acequias and Arroyos	
Risk Assessment	Very Low to Low ▲▲
Sources Affected	• Agua Fria, Alto-Ferguson, Northwest, Osage, Santa Fe, St. Michaels, Torreon; Buckman Wells 1-13
Contaminants of Concern	• Various – depending on local activity contributing to contamination

Concerns

- Acequias are man-made irrigation water distribution systems comprised of unlined ditches and laterals
  - Acequias, like arroyos, are unique sources of recharge to the aquifer and have the potential to transport off-site contaminants derived from the entire upstream contributing area (Finch and Watson 1995)
  - Acequia de los Pinos crosses the Santa Fe SWPA and has reaches that flow seasonally and following urban stormwater or snowmelt runoff
  - A projected LNAPL plume west of St. Francis Drive coincides with the course of Acequia de los Pinos (Hawley 2016)
- Arroyos channel surface water runoff and can be conduits for contaminants to mobilize from one location to another
  - Contaminant concentrations can increase with downstream distance as surface water runoff picks up and accumulates contamination from multiple locations (example: oil from multiple roadways draining to a single arroyo)
- Arroyos are often areas of concentrated and extensive illegal dumping, the contents of which can contain a wide range of contaminants including oils, acids, and heavy metals
- Contaminants can infiltrate from the bed of an unlined arroyo into the groundwater

Strategies

- Collaboration and coordination with Acequia Madre Ditch Association (mayordomo and commissioners) on a contamination mitigation program for the City's acequia system
- Continued public outreach, i.e. Adopt-the-River and Adopt-an-Arroyo programs (managed by Santa Fe Watershed Association on behalf of the City)
- Managing stormwater runoff to reduce contamination carried to arroyos
- Managing illegal dumping in or around arroyos through municipal solid waste programs and public education

Arsenic and Uranium	
Risk Assessment	High ▲
Sources Affected	• Buckman Wells 1-2, 9, 11-13
Contaminants of Concern	• Arsenic (Buckman Wells 1, 9, 1-13) • Uranium (Buckman Well 2)

Concerns

- Arsenic and uranium occur naturally in several Buckman SWPAs
- Arsenic is mobilized in groundwater via water-mineral exchange reactions but its exact stratigraphic source(s) in the Buckman Well Field are unknown (JSAI 2012)
  - Exceedances of arsenic MCL (10 µg/L) ranged from 10.1 µg/L (Buckman Well 1) to 16.9 µg/L (Buckman Well 9) in 2011
  - Arsenic concentrations increased in a southeast direction from Buckman Well 10 to Well 13
- Uranium concentrations may be elevated due to oxidation of deeper aquifer water with shallower, oxygenated water seeping downward along faults (Figure 4-2; JSAI 2012)
  - A 2011 sample from Buckman Well 2 measured 135 µg/L, 4.5x the MCL of 30 µg/L
  - The second highest concentration among Buckman wells occurred at Well 5 (16 µg/L)

Strategies

- The City's contractor, John Shomaker & Associates, Inc., recommended replacing Buckman Wells 1, 6, and 9 at locations away from known fault zones (JSAI 2012). Rehabilitation or replacement were not considered viable for Wells 10-13
- Future aquifer recharge projects in the Buckman Well Field should carefully consider the possibility of remobilizing arsenic and uranium
- Blending of water sources to reduce concentrations of these naturally occurring contaminants is the most cost-effective and practical approach at this time

Athletic Fields, Parks, and Cemeteries	
Risk Assessment	Very Low to Low ▲▲
Sources Affected	• Agua Fria, Alto-Ferguson, Santa Fe, Torreon
Contaminants of Concern	• Fertilizers, herbicides, pesticides • Leachate • Pathogens

Concerns

- Large areas of grass or other landscaping require maintenance that could include regular application of fertilizers and pesticides
  - Nutrients from fertilizer are readily transported in the environment; nitrogen is biologically transformed to nitrate which is highly soluble in water, and phosphorus is easily transported through soil
- Pesticides contain synthetic organic compounds (SOCs) known to cause a variety of health effects
- Pathogens such as *Cryptosporidium* and *E. coli* may be sourced from pet wastes

Strategies

- The City of Santa Fe uses pesticides with natural ingredients at its parks and athletic fields
- Coordination with owners of Fairview Cemetery and private athletic fields to understand and, if needed, improve maintenance practices at those locations
- Continue *Keep it Clean, We're All Downstream* public outreach program to encourage pet waste disposal
- Inventory existing pet waste bag dispensers at parks and determine where more are needed

Buckman Direct Diversion – National Pollutant Discharge Elimination System (NPDES) Permit	
Risk Assessment	Moderate ▲
Sources Affected	• Buckman Wells 1 (Zones C-D) and 2,3, and 8 (Zone D)
Contaminants of Concern	• Metals • Organic/inorganic chemicals • Pathogens • Sewage

Concerns
- The Clean Water Act (CWA) prohibits point source discharges of pollutants into waters of the U.S. through NPDES permits. These permits specify what and how much of a pollutant can be discharged in order to protect human health and water quality
- Water and wastewater treatment plants typically have NPDES permits for the discharge of post-treatment effluent
- The Buckman Direct Diversion Project (BDD; NM3502826) maintains a permit for a major NPDES outfall into the Rio Grande
- The original BDD NPDES permit required reporting of metals, radionuclides, VOCs, and SOCs

Strategies
- BDD monitored the quality of Rio Grande water under their NPDES permit for three years before EPA Region 6 officials determined that the effluent was of sufficiently low risk
- BDD no longer conducts regular sampling of surface water under the permit; however, the Rio Grande is sampled under a separate agreement with Los Alamos National Laboratory (LANL) with the following stipulations:
  - Sampling occurs when storm flows exceed 5 cubic feet per second (cfs) in two Rio Grande tributaries, Los Alamos and Guaje Canyons
  - Samples are tested for suspended sediments, 23 total and dissolved metals plus mercury, radiogenic components (including uranium), dioxin/furans, PCBs, and perchlorate
- NMED Surface Water Quality Bureau reserves the right to amend the NPDES permit if necessary to restore water quality to standards established by the NMWQCC

Commercial PSOCs	
Risk Assessment	Very Low to Moderate ▲▲▲
Sources Affected	• Alto-Ferguson, Santa Fe, St. Michaels

Contaminants of Concern	• Acids • Biohazard wastes • Inks and dyes • Metals • Petroleum hydrocarbons • Radiological wastes • Solvents • Vehicular fluids • Waxes
Concerns • Potential pollutant release from many types of commercial enterprises: automotive and electronics businesses, car washes, laundry services, medical facilities, or paint/print shops • Potential to leach contaminants into soil or groundwater (shallow and/or regional aquifers) • Commercial chemical use often occurs in limited amounts but certain releases can have significant impacts on source water supplies when they continue unmitigated for long periods of time	
Strategies • Consultation with the NMED Ground Water Quality Bureau on new State Cleanup Program, Targeted Brownfield Assessment, or Voluntary Remediation Program sites as needed • Consultation with the NMED Hazardous Waste Bureau on commercial generation of hazardous wastes as defined by the Resource Conservation and Recovery Act (RCRA) • Develop or expand relationships with local businesses and encourage proper control of inventory and use of best management practices • Encourage businesses with confirmed releases to participate in NMED Voluntary Remediation Program • Require new businesses to register their location in relation to source water supplies before approval of licenses	

Electrical Substations	
Risk Assessment	Low ▲
Sources Affected	• Santa Fe, Torreon; Buckman Wells 10 (Zones B-D) and 11 (Zone D)
Contaminants of Concern	• Pesticides • Polychlorinated biphenyls (PCBs)
Concerns • PCBs may be present in dielectric fluids found in electrical transformers, capacitors, and feeder cables at substations • Lightning strikes, corrosion, or fire can cause releases of PCBs from such equipment • Pesticides may be seasonally applied at substations for weed control	
Strategies • Inspect equipment for certification that dielectric fluids contain <50 ppm PCBs per Toxic Substances Control Act (TSCA) and Resource Conservation and Recovery Act (RCRA) requirements • High-visibility labels for PCB-containing equipment on site • Regular inspection of fire hazards and corroded materials	

- Pesticide application should follow site operation and maintenance best management practices (BMPs) with application performed at the lowest possible frequency

Los Alamos National Laboratory (LANL)	
Risk Assessment	N/A
Sources Affected	• Buckman Wells 1-9 (?)
Contaminants of Concern	• Radiogenic materials • Explosive-derived pollutants • Sanitary wastes

Concerns
- Treated and untreated radioactive and chemical wastes have been discharged from activities at Los Alamos National Laboratory (LANL) since the 1940s
- Numerous canyons drain the LANL area, including Los Alamos Canyon which feeds into the Rio Grande 3.5 miles upstream from Buckman Direct Diversion
- Following large wildfires in 2000 and 2011, legacy contaminants began reaching the Rio Grande at historically high rates via suspended sediment transport during storm runoff
- LANL-derived groundwater contamination has not been observed at the Buckman Well Field (ChemRisk 2010) but hydrochemical connections with the Los Alamos area remain uncertain

Strategies
- LANL began sampling for contaminants at Buckman Wells 1, 6, and 8 and two nearby piezometers in 2001. The City of Santa Fe should continue quarterly sampling at these wells
- Continued cooperation between LANL and BDD – and communication with the City of Santa Fe – to monitor/sample surface water in Los Alamos and Pueblo Canyons, triggered by flows of at least 5 cfs capable of reaching the Rio Grande (N3B 2019)
- The City should be prepared to comment on future Environmental Impact Statements or Environmental Assessments required by the National Environmental Policy Act (NEPA) for any operational changes at LANL, including transport of radioactive wastes through the Santa Fe area

Petroleum – Underground Storage Tanks (USTs)	
Risk Assessment	Low ▲
Sources Affected	• Santa Fe, St. Michaels
Contaminants of Concern	• Petroleum hydrocarbons • Volatile organic compounds (VOCs) such as benzene • Synthetic organic compounds (SOCs) such as ethylene dibromide (EDB)

Concerns
- Have the potential to become leaky underground storage tank sites and contaminate groundwater in the shallow and/or regional aquifers
- The Hickox and Santa Fe SWPAs each contain 1 inactive UST; there are 4 inactive USTs in the St. Michaels SWPA

- There are also 21 active or inactive USTs within ½ mile of the City Well Field SWPAs, most located along Cerrillos Road, St. Francis Drive, or St. Michaels Drive • The greater the number of storage tanks, the greater the probability of contamination occurring, increasing the risk to supply wells
Strategies • Periodic review of groundwater reports from the NMED Petroleum Storage Tank Bureau for new leaky underground storage tank sites and periodic review of the New Mexico EnviroMap for new USTs • Land use controls such as setbacks to supply wells

Private Domestic or Agricultural Wells, Other Wells	
Risk Assessment	Very Low ▲
Sources Affected	• Agua Fria, Alto-Ferguson, Osage, Santa Fe, St. Michaels, Torreon; Buckman Wells 1-9, 11-13
Contaminants of Concern	• Any number of organic or inorganic contamination from land use activities near the well
Concerns • Other wells – particularly unregulated private wells - can act as conduits for contamination from the surface to reach groundwater. Private domestic, irrigation, or livestock wells and exploratory wells are included in this category • There are 73 wells within the City SWPAs and 28 within the Buckman SWPAs • Buckman SWPAs 1, 3, and 13 have wells in SWP Zones B and/or C. All other Buckman SWPAs have wells in Zone D only • The greater the number of wells, the greater the probability of contamination occurring, increasing the risk to municipal supply wells	
Strategies • Confirm screened depths of existing wells (shallow versus regional aquifer) • Coordination with the New Mexico Office of the State Engineer to ensure abandoned wells are properly plugged • Santa Fe City Ordinance #2004-7, § 1, *Regulations for the drilling of new domestic water wells*, requires that private domestic wells drilled within the city limits must be permitted by the Water Division Director following approval of a permit from the Office of the State Engineer - If approved, domestic wells must be located more than 300 feet from an existing water distribution line, unless the cost of connecting to the existing line exceeds the cost of drilling a new well - Domestic wells must be metered with monthly use reported to the Water Division - In certain areas, domestic wells must be drilled at least 50 feet into the Tesuque Formation and properly sealed to prevent mixing with the shallow aquifer	

Railroad Yards and Tracks	
Risk Assessment	High ▲

Sources Affected	• Hickox (?), Santa Fe (?), St. Michaels (Figure 5-3)
Contaminants of Concern	• Metals • Pesticides • Petroleum hydrocarbons • Polycyclic aromatic hydrocarbons (PAHs) • Solvents

Concerns
- Potential for releases of large amounts of fuels, pesticides sprayed seasonally along tracks, or other organic chemicals used during maintenance operations
- Potential to leach contaminants into soil or groundwater (shallow and/or regional aquifers)

Strategies
- Coordination with emergency response officials, e.g. Santa Fe Fire Department
- Coordination with railway operators and maintenance crews on activities with the potential to release contaminants
- Pesticide application should follow operation and maintenance BMPs with application performed at the lowest possible frequency

Roads

Risk Assessment	Low to Moderate ▲▲
Sources Affected	• Agua Fria, Alto-Ferguson, Hickox, Northwest, Osage, Santa Fe, St. Michaels; Buckman Wells 1-13
Contaminants of Concern	• Asphalt • Automotive wastes, diesel fuels, gasoline, • Hazardous wastes • Pesticides, road salt • Radiogenic materials • Sediment, sewage, stormwater runoff • Solvents

Concerns
- Dirt roads and paved roads can accumulate chemicals from vehicles or roadside activities such as pesticide sprays and salting during winter weather. Any chemicals present on roadways may runoff into water supplies during storm events, particularly on paved, impervious surfaces
- Erosion can happen quickly on dirt roads during intense precipitation, freeing sediment that can collect in nearby water resources
- Chemical spills from accidents or leaks during transport on roadways also threaten water quality

Strategies
- Design and construction of drainage systems associated with roadways should consider the potential accumulation of chemicals in nearby water supplies (surface or groundwater)
- Pesticide application should follow BMPs with application performed at the lowest possible frequency
- Regular maintenance of dirt roads to control erosion

- Santa Fe relief route (NM Highway 599) circumvents some long-distance transport of chemicals and other potentially harmful substances around the city limits
- Vehicular travel on dirt roads crossing SWPAs should be limited to the extent possible (through Buckman Well Field and Northwest Well SWPA)
- Water quality BMPs should be implemented during all new road construction

Septic Systems	
Risk Assessment	Very Low ▲
Sources Affected	• Agua Fria, Alto-Ferguson, Buckman Well 13, Osage, Santa Fe, St. Michaels, Torreon
Contaminants of Concern	• Chloride • Fuels • Metals • Nutrients (nitrate, ammonia) • Pesticides, herbicides • Septage, pathogens • Solvents / cleaning agents

Concerns

Figure 6-2 Septic tank improperly covered by plywood and corrugated tin. Courtesy of NMED Liquid Waste Program.

- Improperly maintained (Figure 6-2) and/or leaking septic systems leading to potential contamination of source water in upper or lower aquifers
- The NMED *Wastewater Treatment System Permit Finder* does not list any currently permitted septic systems within the City Well Field and only one within the Buckman Well Field. As a precaution, parcels within the well fields without confirmed connections to a municipal sewer system were included in the potential contaminant source inventory. These parcels are mostly in the Agua Fria, Alto-Ferguson, Buckman Well 13, and Osage SWPAs, but their inclusion in the dataset does not imply that septic tanks or leachfields have been confirmed to exist at these locations
- The greater the number of septic systems, the greater the probability of contamination occurring, increasing the risk to supply wells

Strategies

- Conduct inventory of suspected parcels for the presence/absence of septic systems
- New development should be connected to the City's sewer system
- Public outreach and coordination with the local NMED Environmental Health Bureau office to provide information to septic system users in the SWPAs regarding septic systems
- Water conservation incentives
- Santa Fe City Ordinance #1997-3, § 13-26, *Septic tanks, constructed wetlands, or other on-site private sewage disposal systems*, defines the permitting process for septic systems within city limits

where connection to the sanitary sewer system is not possible and requires that septic tank and private sewage disposal system construction complies with applicable regulations

Stormwater Collection Areas and Outlets	
Risk Assessment	Low ▲
Sources Affected	• Agua Fria, Alto-Ferguson, Osage, Santa Fe, Torreon
Contaminants of Concern	• Automotive wastes, gasoline, oil • Fertilizer, herbicides, nitrate, pesticides, phosphate • Organic/inorganic chemicals • Pathogens • Runoff
Concerns • Stormwater runoff can be a significant source of pollution, especially in urban areas where runoff may be significant due to greater areas of impervious (paved) surfaces preventing infiltration • Runoff may contain many types of pollutants and is ultimately discharged to collection ponds or the Santa Fe River via a series of drains and outlets	
Strategies • Continued implementation of City of Santa Fe NPDES Municipal Separate Storm Sewer System (MS4) permit program and minimum control measures of Storm Water Management Plan • Continued cooperation with NPDES MS4 co-permitees (Santa Fe County and NM Department of Transportation District 5) • Coordination with the New Mexico Office of the State Engineer to ensure abandoned wells susceptible to runoff are properly plugged • Continued public outreach, e.g. City of Santa Fe Stormwater Planning Facebook page and Adopt-the-River and Adopt-an-Arroyo programs (managed by Santa Fe Watershed Association on behalf of the City) • Continue to identify new funding sources for vegetation projects to promote infiltration including replacement of dead or dying trees and infiltration gardens (e.g., TreeSmart Santa Fe) • Santa Fe City Ordinance #2005-3, § 2-19, *Stormwater illicit discharge control*, prohibits illicit discharges and connections to the city's storm drain system and requires citizens to keep their land free of pollutants and prevent bank erosion if watercourses transect their property	

6.4 Potential Sources of Contamination – Surface and Groundwater

Climate Change and Drought	
Risk Assessment	N/A
Sources Affected	• All drinking water sources

Contaminants of Concern	• Drought is frequently considered a greater issue for water quantity but can also impact water quality. For example, decreased flows resulting from a poor snowpack could compromise the Santa Fe River's natural ability to dilute contamination

Issues

The onset of multi-year drought (megadrought) in New Mexico from the late 1990s to 2002 underscored the need for greater climate resiliency among water systems in the Southwest. Recognizing long-term trends in groundwater overuse, the City of Santa Fe began implementing water conservation programs in the mid-1990s that enjoyed widespread public support. This coincided with the City's purchase of the water utility from PNM.

Still, the late-90s drought posed significant issues for the reliability of drinking water resources in the Santa Fe area and, in light of continued population growth, spurred the City and Santa Fe County to seek a sustainable alternative. Buckman Direct Diversion Project was built in 2011 to serve this need, but it was thought that the City would still fall short of projected demands for potable and non-potable water by 2021, even with the additional San Juan-Chama water (CDM 2008).

Water conservation programs continued to see success in Santa Fe, with per capita daily consumption from 1995 to 2019 falling 48% despite a nearly 150% increase in population over that same interval of time (CSF 2020). The availability of additional surface water via Buckman Direct Diversion has allowed the City to greatly reduce its reliance on groundwater supplies, which totaled only 7% of all production in 2019 (although that year saw a much-improved snowpack over 2018).

The occurrence of another megadrought could offset the City's successes with balancing surface and groundwater sources as could the emergence of other issues linked to drought. Forest die-off due to bark beetle infestation, more frequent and more severe wildfires, and earlier onset of spring snowmelt runoff are examples of natural processes that are exacerbated by drought, potentially leading to deleterious impacts on both water quantity and quality.

Concerns

- The following scenarios are projected to impact water resources in the Santa Fe area (Lewis et al. 2013):
  - Increased temperatures
  - Diminished snowpack, earlier spring runoff, and reduced peak flows
  - Generally reduced streamflow due to greater evaporation rates and interception by vegetation
  - Drier mid- to late summers (coinciding with monsoon season)
  - More frequent and severe droughts
  - Increased fire activity and risk of catastrophic fire
  - More intense precipitation events leading to greater flooding, higher erosion rates, and sediment transport
- Decreased surface water availability potentially leading to renewed and perhaps excessive reliance on groundwater supplies
- Demand hardening: the point at which long-term increases in water-use efficiency can no longer reduce demand, particularly during extended water shortages
  - May occur once the easiest and least expensive conservation measures have been exhausted

Strategies

- Initiate, continue, or renew action items described in *Climate Change and the Santa Fe Basin: A Preliminary Assessment of Vulnerabilities and Adaptation Alternatives* (Lewis et al. 2013):
  - Limit domestic well permits and use for residential and commercial groundwater pumping
  - Develop infrastructure and programs for groundwater storage and recovery

- Preserve and protect water saved by conservation initiatives
- Increase water storage capacity
- Evaluate successes and needs of conjunctive water management plan with Santa Fe County
- Evaluate successes and needs of long-term water supply plan
- Continue Santa Fe River flow program to replenish groundwater throughout its urban reach
- Continue wastewater reclamation program and assess opportunities for expansion
- Continue tiered municipal water rate program (users who use less pay less)
- Continue measures defined under the water conservation ordinance (see below) and seek opportunities for expansion of these programs

• Work with Buckman Direct Diversion and other stakeholders to pursue completion of the San Juan-Chama return flow pipeline:
- Unused San Juan-Chama water will be returned to the Rio Grande for return flow credits and/or increases in transfers to the City's upstream water storage quantities
- Credits/transfers will bolster the City's water resiliency under scenarios of a changing climate and increased population

• Santa Fe City Ordinance #1997-17, § 2-8, *Comprehensive water conservation requirements*, allows the City to require residents and businesses to comply with water conservation regulations and also establishes financial incentives for such activities:
- Toilet retrofitting program
- Rebates for water-efficient appliances
- Rebates for moisture sensors and evaporation controllers for landscape watering systems
- Gray-water code promoting the use of household wastewater for landscape watering
- Green-building code that includes a water-harvesting element
- Free water-leak detection audits for customers with high water usage

• Santa Fe City Ordinance #2006-53, § 19-32, *Water emergency management plan*, provides the City with the means to control water use in response to water-system-related emergencies or water emergencies due to catastrophic events or prolonged drought that may disrupt system operations or water sources

• Santa Fe City Council Resolution No. 2011-17 directed City staff to prepare revisions to the City's long-range water supply plan (CDM 2008) with a specific emphasis on climate change. This resulted in the *Santa Fe Basin Study: Adaptations to Projected Changes in Water Supply and Demand* (2015)

Wildfire	
Risk Assessment	High to Very High ▲▲
Sources Affected	• Upper Santa Fe River watershed, including McClure and Nichols Reservoirs
Contaminants of Concern	• Ash • Debris flows • Dissolved organic carbons • Fire-fighting foams and associated chemicals • Metals • Nutrients • Suspended sediment

Issues

New Mexico has experienced a number of catastrophic wildfires that burned huge acreages and destroyed property. Although the Upper Santa River watershed has not burned in recent history, large fires impacted neighboring watersheds including the 2013 Jaroso and Tres Lagunas fires in the

Pecos watershed and the 2020 Medio fire in the Rio Nambe watershed. The wildfire season in the southwestern United States has been trending longer with larger fires over the last several decades.

Wildfires can cause significant impairment to source waters and drinking water infrastructure located in areas susceptible to burning. Wildfire and post-fire impacts to water systems depend on a multitude of factors ranging from forest type, climatic conditions, geology and topography, fire severity and intensity, and the nature of the water system – including a system's level of preparedness for catastrophic fires.

Surface water systems are likely to experience more immediate and long-term effects than are groundwater systems, but the infrastructure of both types of systems is vulnerable. Water systems may be at risk of deposition of ash, treefalls, and other effects that occur as fires burn, but post-fire processes such as flooding, landslides, and debris flows are often of even greater concern to both source water quality and infrastructure.

Concerns

- Physical damage to surface water intakes and treatment plants may occur both during and after fires
- Debris flows – fast-moving, gravity-driven mixtures consisting of a liquified, unconsolidated, and saturated mass of loose particles – can cause both structural and water quality impairments
- Water quality impairment due to increased metals, nitrates, dissolved organic carbon, and turbidity often manifest as short-term (hours to days) impacts but may last for over a year after a given fire (Sham et al. 2013)
  - Nutrients may be sourced from flame retardants used for firefighting. These may contain ammonium phosphate, for instance
  - Excess nutrients can lead to algal blooms in reservoirs
- Reservoir sedimentation and decreases in storage capacity have been observed on both short and long (weeks to years) timeframes
  - Increased debris in reservoirs can also affect the structural integrity of dams
- Wildfire impacts can lead to expensive changes in treatment techniques, reservoir operation and maintenance, and watershed management

Strategies

- Continue mechanical thinning, prescribed burns, and follow-up forest treatment practices (e.g., removal of non-native species)
  - Figure 6-3 shows actual and proposed forest treatment areas in the Upper Santa Fe River watershed
  - Explore new treatment funding opportunities, e.g., from the New Mexico State Forestry Office
- Short-term watershed management: sediment traps, adjust BMPs for individual sub-catchments
- Long-term watershed management: invest in updated reservoir infrastructure, forest thinning projects and fuel breaks
- Adaptive management framework:
  - Phase 1: inventory risks, assess the state of the watershed, and prioritize needs
  - Phase 2: evaluate (e.g., return-on-investments, lessons learned) and plan (SWPP)
  - Ongoing: monitoring and implementation of BMPs
- Santa Fe City Ordinance #2003-25, § 33, *Santa Fe River watershed; prohibited uses; posting of notices*, forbids most public activities within the upper Santa Fe River watershed, punishable by a fee of up to $500 or 90 days in prison
  - The closed watershed is less vulnerable to human causes of wildfires
  - The closing of the watershed also protects the City's reservoirs and the river from other potential sources of contamination that might occur from typical uses of National Forest land. For instance, the lack of grazing leases in the municipal watershed means that wastes from cows or other free-roaming livestock will not contaminate drinking water

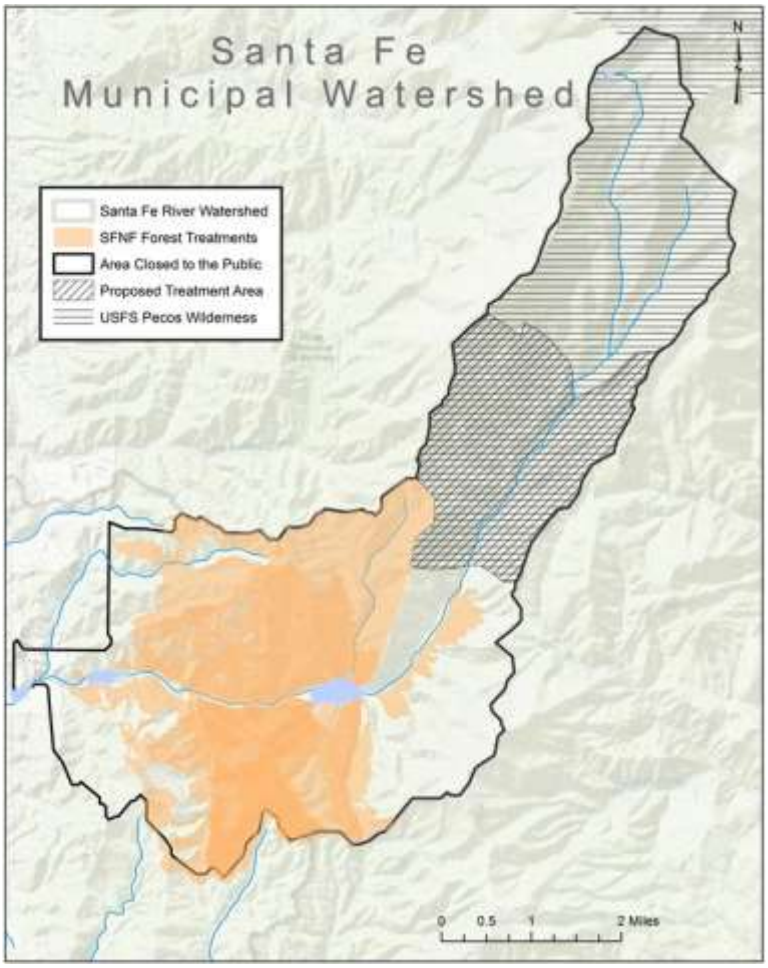


Figure 6-3 Forest treatment areas in the Upper Santa Fe River watershed (City of Santa Fe Water Division).

7.0 PUBLIC OUTREACH

The City of Santa Fe and its community partner, the Santa Fe Watershed Association, have numerous public education and outreach programs designed to educate residents on all facets of the City's water system and sources. Some of these are described in Section 6 as successful, ongoing strategies that directly address one or more source water protection issues. Programs are evaluated by the City of Santa Fe Water Conservation Committee on a regular basis.

Table 7-1 describes water conservation programs in Santa Fe including public outreach and education efforts. Recommendations are provided that could further expand the beneficial impact of each program.

Table 7-1 Water conservation programs offered by the City of Santa Fe and its partners

Program Name	Managing Organization	Function / Source Water Issues	Future Strategies and Direction
Adopt-an-Arroyo	Santa Fe Watershed Association / CSF	Litter removal, erosion reduction (5x per year)	Seek additional funding, e.g. crowdsourcing

Adopt-the-River	Santa Fe Watershed Association / CSF	• Litter removal and invasive species removal training • Funded by tax-deductible contributions from businesses and community groups	Seek additional funding, e.g. crowdsourcing
Annual cleanup events	Santa Fe Watershed Association	• Litter removal • Three annual events: -Love Your River Day (Feb) -Summer River/Arroyo Rescue (mid-summer) -Hunt for Red Rocktober (Oct)	• Merge with or clarify relationship to Adopt-the-River and Adopt-an-Arroyo programs as the goals are similar • Pair with municipal hazardous waste collection event to increase impact on PSOC mitigation
Children's Water Fiesta (Annual)	City of Santa Fe Water Conservation Office	Hands-on learning demonstrations for 4th grade students at Santa Fe Public Schools	Open events to all students of the appropriate age in Santa Fe
Green Lodging Initiative	Santa Fe Watershed Association	Implement Santa Fe Green Concierge Certification™ program, including water conservation measures	Increase advertising of program via City events and social media
Keep it Clean, We're All Downstream	City of Santa Fe Water Conservation Office	Pet waste disposal brochure and video	Increase advertising of program via City events and social media
Leak detection service	City of Santa Fe Water Conservation Office	Free evaluation of water fixtures to decrease water waste	Increase advertising of program via City events and social media
My Water, My Watershed	Santa Fe Watershed Association	• Field trip to upper Santa Fe River watershed for 5th grade students at Santa Fe Public Schools • Follow-up activities for 6th graders.	• Open events to all students of the appropriate age in Santa Fe • Evaluate opportunities for greater synergy with watershed monitoring program for middle- and high-school students to create long-term youth watershed program
NM Climate Masters	Santa Fe Watershed Association	• 30-hour course (10 weeks) on climate change and water, soil, food production, etc. • Includes field trip	Increase participant capacity and advertising for program to compensate for course not being held in 2020 due to COVID-19 pandemic
Project WET (Water Education for Teachers) Workshop (annual)	City of Santa Fe Water Conservation Office	Interactive water resources activities for upper elementary or middle-school curricula	• Increase advertising for program at City events and on social media

			• Seek funding opportunities to decrease cost for participants
Qualified Water Efficient Landscape (QWEL) Training	City of Santa Fe Water Conservation Office	Training on and certification for water-efficient and sustainable practices for professional landscapers	• Does program still exist? (CSF website lists 2015 date) • Increase advertising for program at City events and on social media • Seek funding opportunities to decrease cost for participants
Rain Gardens	Santa Fe Watershed Association / CSF	Interception gardens for stormwater infiltration	Consider new rain gardens where absent in SWPAs (Agua Fria, Santa Osage, Fe, St. Michaels, and Torreon), Alameda Rain Garden Program
Rebates (commercial)	City of Santa Fe Water Conservation Office	Rebates on purchases of efficient or water-free toilets and urinals or custom retrofit projects	• Evaluate funding opportunities to increase rebate values • Explore new advertising opportunities
Rebates (indoor)	City of Santa Fe Water Conservation Office	Rebates on purchases of efficient toilets, washing machines, and dishwashers	• Evaluate funding opportunities to increase rebate values • Explore new advertising opportunities
Rebates (outdoor)	City of Santa Fe Water Conservation Office	Rebates on installations of rain and soil moisture sensors and gray-water systems	• Evaluate funding opportunities to increase rebate values • Explore new advertising opportunities
Santa Fe Municipal Watershed Hikes	Santa Fe Watershed Association / CSF	Guided Upper Santa Fe River watershed hikes led by watershed management experts	Offer hikes during ongoing watershed activities (e.g., thinning, dam maintenance) in a safe manner
Santa Fe Rain Watchers	City of Santa Fe Water Conservation Office	Volunteers monitor precipitation using rain gages provided by the City	• Link to Community Collaborative Rain, Hail & Snow Network map on City website • Have sign-up forms available at all water-related events hosted by the City
Santa Fe River Fishing Derby (annual)	City of Santa Fe Water Conservation Office / New Mexico Game and Fish	Free fishing derby for stocked rainbow trout, including kid's derby, from Don Gaspar Ave. to Old Santa Fe Trail	Stage booths along the derby reach with information on source water protection,

			watershed management, etc.
Santa Fe River Talks	City of Santa Fe Water Conservation Office	Summer lecture series on watershed BMPs and water system activities	Broadcast as webinars and post to social media for those unable to attend in person
Save Water Santa Fe	City of Santa Fe Water Conservation Office	Outreach website with information on water conservation programs and links to social media	• Continue approximately bi-monthly blog posts on water issues • Link to and advertise Santa Fe Watershed Association projects
STEM internship (high school students)	City of Santa Fe Water Division	Introduction to conservation careers with focus on riparian and forest fuels management assessments supervised by watershed specialists	• New program – evaluate successes and address shortcomings • Expand program as funding opportunities allow
Value Water campaign	City of Santa Fe Water Conservation Office	Series of short videos on the importance of water to the culture and economy of Santa Fe from Save Water Santa Fe	• Continue video production and posting to social media • Produce new videos on contamination, climate change threats
Watershed monitoring (students)	Santa Fe Watershed Association	Field trip to collect data on water quality, biology, and forest health for middle- and high-school students at Santa Fe Public Schools	• Open events to all students of the appropriate age in Santa Fe • Organize science fair event for students to present their findings to a greater audience
Other tours and outdoor classes	City of Santa Fe / Santa Fe Community College / New Mexico Highlands Univ. / Univ. New Mexico / Colorado School of Mines	Ecology and watershed management courses	• Encourage student projects that identify innovative source water management solutions (e.g., Masters theses) • Evaluate funding opportunities on behalf of the City for such projects

8.0 RECOMMENDED ACTION ITEMS AND STRATEGIES

Many strategies for source water management and protection are described in Section 6 with additional recommendations for increasing the impact of public outreach and water conservation programs provided in Section 7. The recommended action items below include general guidelines for near- and long-term source water protection efforts and are meant to provide a framework for collaboration with various stakeholders. Some of these strategies were originally identified by Daniel B. Stephens and Associates, Inc., in an unpublished draft Source Water Protection Plan submitted to NMED (DBSA 2017).

The following recommendations are made for Santa Fe's implementation of the Source Water Protection Program:

- The City should designate a Source Water Protection Team lead or chair to coordinate updates to this plan and assessment, implementation of action items, and collaborative efforts once regular NMED assistance ends.

- Representation on the Source Water Protection Team should be expanded to better inform the plan and implement recommended action items. Consider adding members representing the U.S. Forest Service, members of the public, members of community water groups (e.g., Santa Fe Watershed Association), and one or more members from economic sectors within the City.

    - Participation from Santa Fe's business community is key as source water information is not always readily available to commercial enterprises.

    - Develop an easy-to-use online system/tool or web map to notify new businesses of their proximity to and concerns over the City's SWPAs/water system infrastructure and PSOCs, respectively.

    - See Truckee Meadows Water Authority (Nevada) SWP Business Notification Tool for an example that is encoded into city ordinances: https://swpp.tmwa.com.

- The Source Water Protection Team should meet to review and discuss this draft plan in detail, including additional information on the system and potential sources of contamination as that information becomes available.

- Coordinate updates to the Santa Fe SWPP with updates to the Buckman Direct Diversion SWPP and vice versa, as the latter supplies a significant proportion of the City's source water.

- The Source Water Protection Team should meet annually to review the delineation of the City's SWPAs the contaminant source inventories within the delineated SWPAs, and any changes to the system's sources.

    - The SWPP, contaminant source inventory, and risk assessment for PSOCs and SOCs should be updated on an annual basis.

- The Source Water Protection Team should participate as necessary in regulatory meetings and hearings on facilities within the City's SWPAs.

- Continue wildfire mitigation efforts such as thinning and prescribed burning with added focus on the risk of debris flows in the upper Santa Fe River watershed.

- Consider initiating an educational campaign for septic system owners informing them of proper maintenance and risk of contamination resulting from improper care.

• Evaluate the need for and feasibility of zoning restrictions near municipal wells within the City limits.

• Capture zones should be defined for all 13 Buckman Well Field wells, using a model with the most up-to-date hydrogeologic and hydraulic data, by a contractor of the City's choosing.

• Monitor arsenic levels in the Buckman Well Field and consider well rehabilitation options as necessary.

• Monitor uranium levels in Buckman Well 2 and consider well rehabilitation options as necessary.

• A public information program should be developed that is specific to source water protection. This program would educate the public about the City's water sources, potential threats to those sources, and measures that the public can take to protect sources and would encourage the public to report PSOCs to the Source Water Protection Team.

- Coordinate this program with other water conservation and public outreach programs sponsored by the City and/or Santa Fe Watershed Association.

- Work with NMED and the City's GIS team to develop a user-friendly, online story map explaining the importance of source water protection for the public.

- Advertise the program via various social media outlets.

• Any materials produced for public outreach such as those described above should also be made available in Spanish due to its prevalent use in New Mexico.

• A data and report clearinghouse should be developed by the City and hosted on its webpage. This will allow convenient access to an extensive body of literature about the City's source water for public and technical stakeholders alike.

• Environmental justice actions should be considered during all source water activities in order to ensure equitable water quality for all residents of Santa Fe.

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APPENDIX I

Geomorphic units mapped in the Upper Santa Fe River watershed

INTRODUCTION

A variety of geomorphic units are found in the Upper Santa Fe River (USFR) watershed, including alluvial, colluvial (hillslope), fluvial, lacustrine (lake) mass movement, and glacial deposits.

This mapping effort was performed as part of the development of a source water protection plan (SWPP) for the City of Santa Fe, New Mexico. The mapped area is shown in Figure 5-4

METHODS

Geomorphic units in the USFR watershed were mapped remotely using digital elevation models (DEMs) produced through the 3D Elevation Program (3DEP) at the U.S. Geological Survey. These bare-earth DEM tiles are derived from light detection and ranging (LiDAR) source data and feature standard 1-m resolution. The original LiDAR survey covered Santa Fe County in 2014.

Surface characteristics such as smoothness and vegetation patterns as well as landscape position were used to distinguish younger from older deposits. Comparisons were made to locally and regionally mapped and dated geomorphic units (e.g., Koning and Read 2010).

No attempt was made to correlate terrace deposits across USFR tributaries because of highly variable incision histories. However, terrace deposits in the uppermost watershed are likely Late Pleistocene in age because they are inset into glacial till deposits inferred to correlate to the MIS 6 Bull Lake glaciation.

GEOMORPHIC UNITS OF THE UPPER SANTA FE RIVER WATERSHED

Recent Units

daf Disturbed ground or artificial fill (Recent)
Rac Alluvium in channels intermittently obscured by reservoir highstands (Recent)
Ral Mixed alluvium and lacustrine sediment intermittently obscured by reservoir highstands (Recent)
Rl Lacustrine sediment intermittently obscured by reservoir highstands (Recent)
Rw14 Water bodies apparent in NAIP 2014 imagery (Recent)

Valley-Floor and Terrace Units

Qam Modern alluvium (<100 yr old)
Qah Historical alluvium (Probably <200 yr old)
Qar Recent alluvium (Probably <200 yr old)
Qay Younger alluvium (Holocene)
Qao Older alluvium (Probably Late Pleistocene to Early Holocene)
Qamh Modern and subordinate historical alluvium, undivided (Probably <200 yr old)
Qamy Modern and subordinate younger alluvium, undivided (Holocene)
Qahm Historical and subordinate modern alluvium, undivided (<200 yr old)
Qahy Historical and subordinate younger alluvium, undivided (Holocene)
Qary Recent and subordinate younger alluvium, undivided (Holocene)
Qaym Younger and subordinate modern alluvium, undivided (Holocene)
Qayh Younger and subordinate historical alluvium, undivided (Holocene)
Qayr Younger and subordinate recent alluvium, undivided (Holocene)
Qgts Santa Fe River terrace deposits, undivided (Late Pleistocene?)

Alluvial-Fan Units

Qfm Modern fan alluvium (<100 yr old)
Qfh Historical fan alluvium (<200 yr old)
Qfy Younger fan alluvium (Holocene)
Qfo Older fan alluvium (Late Pleistocene to Early Holocene)
Qfmh Modern and subordinate historical fan alluvium, undivided (<200 yr old)
Qfhm Historical and subordinate modern fan alluvium, undivided (<200 yr old)
Qfhy Historical and subordinate younger fan alluvium, undivided (Holocene)
Qfry Recent and subordinate younger fan alluvium, undivided (Holocene)
Qfym Younger and subordinate modern fan alluvium, undivided (Holocene)
Qfyh Younger and subordinate historical fan alluvium, undivided (Holocene)
Qfyr Younger and subordinate recent fan alluvium undivided (Holocene)

Hillslope and Mass Wasting Units

Qc Colluvium (Late Pleistocene(?) to Holocene)
Qca Colluvium and alluvium, undivided (Late Pleistocene(?) to Holocene)
Qcs Colluvium and slopewash, undivided (Late Pleistocene(?) to Holocene)
Qct Colluvium and subordinate talus, undivided (Late Pleistocene(?) to Holocene)
Qcts Colluvium, talus, and slopewash, undivided (Late Pleistocene(?) to Holocene)
Qt Talus (Late Pleistocene(?) to Holocene)
Qtc Talus and subordinate colluvium, undivided (Late Pleistocene(?) to Holocene)
Qls Landslide deposits (Late Pleistocene(?) to Holocene)

Debris-Flow Units

Qdm Modern debris-flow deposits (<50 yr old)
Qdh Historical debris-flow deposits (<100-200 yr old)
Qdy Younger debris-flow deposits (Holocene)
Qdo Older debris-flow deposits (Late Pleistocene(?) to Holocene)
Qdmy Modern and subordinate younger debris-flow deposits, undivided (Holocene)
Qdhy Historical and subordinate younger debris-flow deposits, undivided (Holocene)
Qdyh Younger and subordinate historical debris-flow deposits, undivided (Holocene)
Qdyo Younger and subordinate historical debris-flow deposits, undivided (Late Pleistocene(?) to Holocene)
Qady Younger debris-flow deposits subject to reworking by running water (Holocene)
Qado Older debris-flow deposits subject to reworking by running water (Late Pleistocene(?) to Holocene)
Qadyh Younger and subordinate historical debris-flow deposits subject to reworking by running water (Holocene)
Qadoy Older and subordinate younger debris-flow deposits subject to reworking by running water (Late Pleistocene(?) to Holocene)

Glacial and Periglacial Units

Qgop Pinedale outwash deposits (Late Pleistocene)
Qgty Younger glacial till (Latest Pleistocene to Early Holocene)
Qgtp Pinedale glacial till, undivided (Late Pleistocene)
Qgtb Bull Lake glacial till, undivided (Late Middle Pleistocene)
Qrg Rock glacier deposit (Holocene)

Qrgt Rock glacier deposit and subordinate talus deposits (Holocene)
Qrgo Older rock glacier deposit (Latest Pleistocene(?))

Bedrock Units
XYu Igneous and metamorphic basement rocks, undivided (Paleo- to Mesoproterozoic)